OPERATING AND MAINTENANCE MANUAL

DUMONT

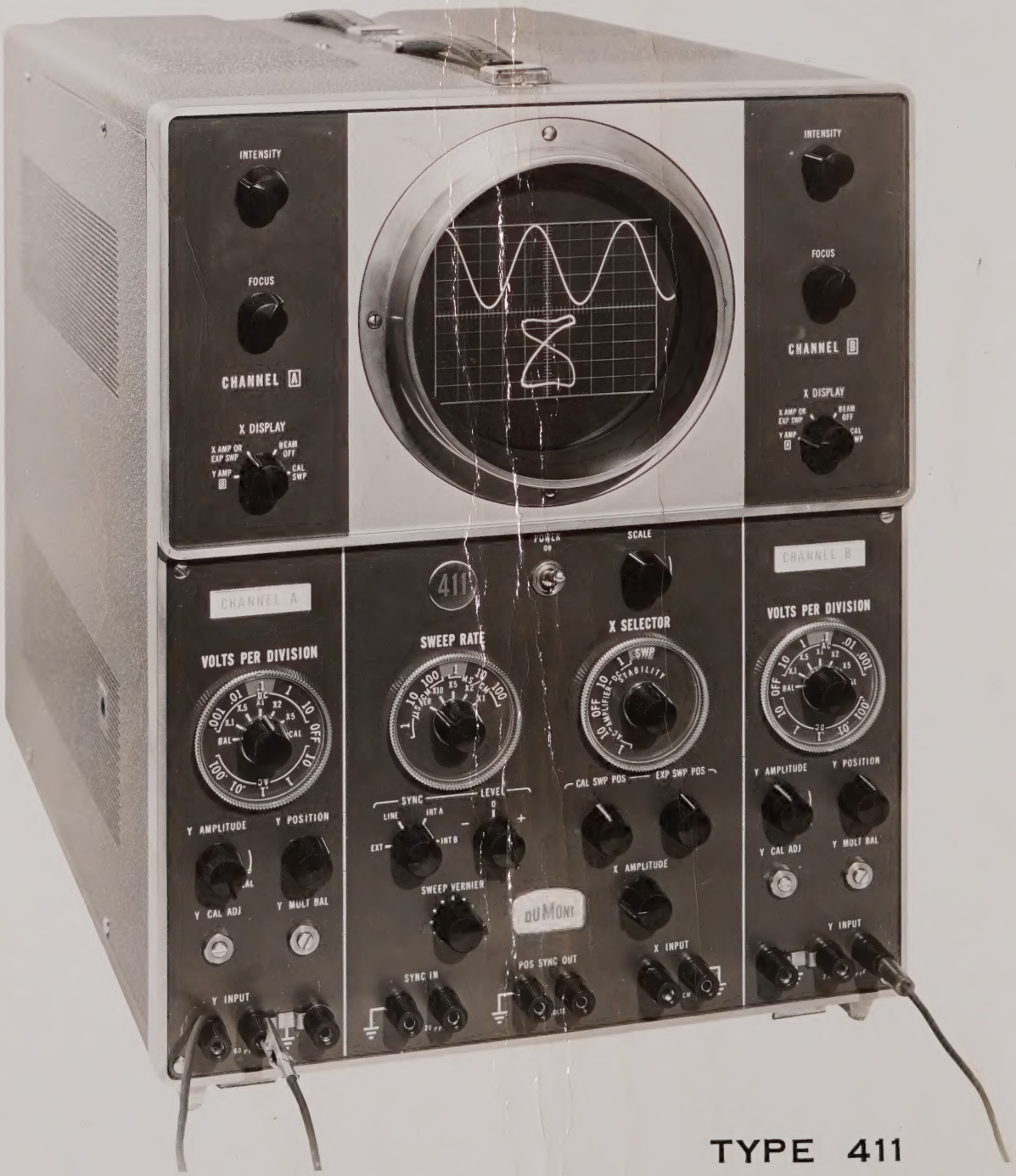
TYPES 411 and 411-R

CATHODE-RAY OSCILLOSCOPE

ALLEN B. DUMONT LABORATORIES, INC.

TECHNICAL PRODUCTS DIVISION

760 BLOOMFIELD AVENUE, CLIFTON, N. J., U. S. A.


INTENSITY
FOCUS
CHANNEL A
X DISPLAY
X AMP OR EXP SWP
BEAM OFF
Y AMP B
CAL SWP
INTENSITY
FOCUS
CHANNEL B
X DISPLAY
CHANNEL A
VOLTS PER DIVISION
Y AMPLITUDE
Y POSITION
Y CAL ADJ
Y MULT BAL
Y INPUT
411
POWER ON
SCALE
SWEEP RATE
X SELECTOR
SYNC
LEVEL
LINE
INT A
EXT
INT B
SWEEP VERNIER
CAL SWP POS
EXP SWP POS
X AMPLITUDE
X INPUT
SYNC IN
POS SYNC OUT
DUMONT
CHANNEL B
VOLTS PER DIVISION
Y AMPLITUDE
Y POSITION
Y CAL ADJ
Y MULT BAL
Y INPUT

TYPE 411

INSTRUCTION SHEET

DU MONT TYPE 2592 TERMINAL ADAPTERS

1. GENERAL

The Du Mont Type 2592-( ) Terminal Adapters are designed to permit the use of coaxial cables for carrying the input signal to an oscillograph where such oscillograph has banana-jack type terminals spaced 3/4 inch on centers. One of the standard R-F type coaxial jacks (UHF, Type N, or Type BNC) is supplied on each adapter to fit the appropriate corresponding coaxial plug. Those adapters employing Type N or Type BNC connectors are so identified by the letters "N" or "B", respectively, stamped on the Adapter shell following the 2592 type designation and immediately preceding the impedance identification. Where no letter appears in the type designation, a UHF type connector is implied.

2. TERMINATION CONSIDERATION

Built into the adapter is a terminating resistance for the coaxial cable. The last two digits of the type number, shown on one side of the adapter, gives the impedance of the cable with which it must be used.

3. TERMINATION FOR ESPECIALLY LOW STANDING-WAVE RATIO

The terminating resistors furnished in these adapters are the nearest 5% RMA value to the surge impedance of the cable. If a very low standing-wave ratio is desired at the termination, it is suggested that a special low-tolerance resistor be installed. It should be kept in mind, however, that the cable impedance may vary by approximately $\pm 5\%$, and this factor may make it necessary for the terminating resistance to be selected for each particular cable if the lowest possible standing-wave ratio is desired.

4. REPLACEMENT OF TERMINATING RESISTOR

When replacing the terminating resistor, it is necessary to remove three screws and loosen a fourth to gain access to the inside of the adapter shell. (See Figure 1). Remove the half of the shell opposite the nameplate as follows:

1. Loosen the flat-head screw next to the coaxial connector (do not remove the screw);
2. Remove the two binder-head screws holding the coaxial connector to the half of the shell being removed;
3. Remove the flat-head screw in the side of the shell;
4. Pull the shell apart thus exposing the terminating resistor as shown.

Part No. 67006442

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CLIFTON, NEW JERSEY, U. S. A.

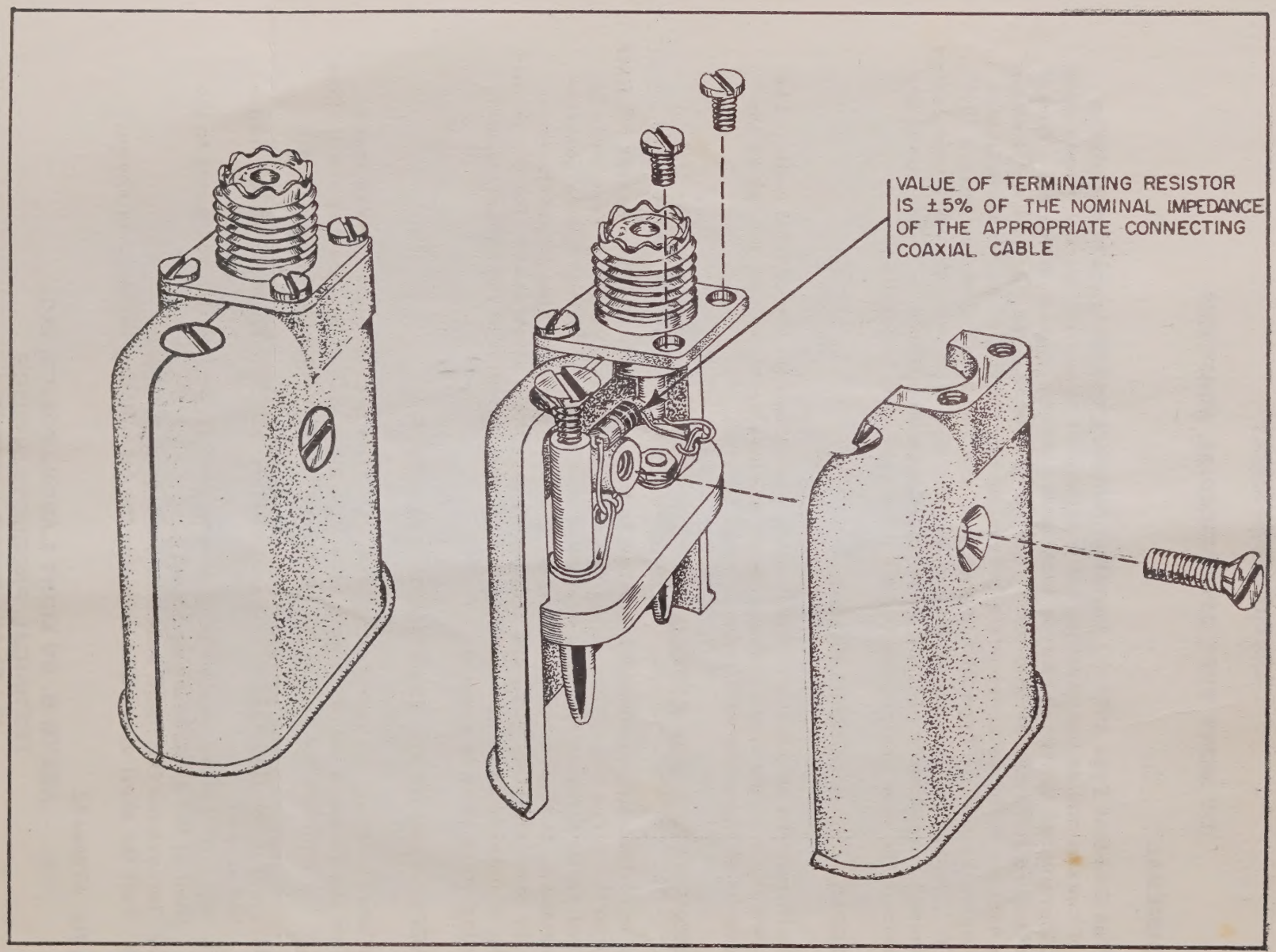

FIGURE 1. DU MONT TYPE 2592-( ) TERMINAL ADAPTER SHOWING METHOD FOR GAINING ACCESS TO TERMINATING RESISTOR

INSTRUCTION SHEET

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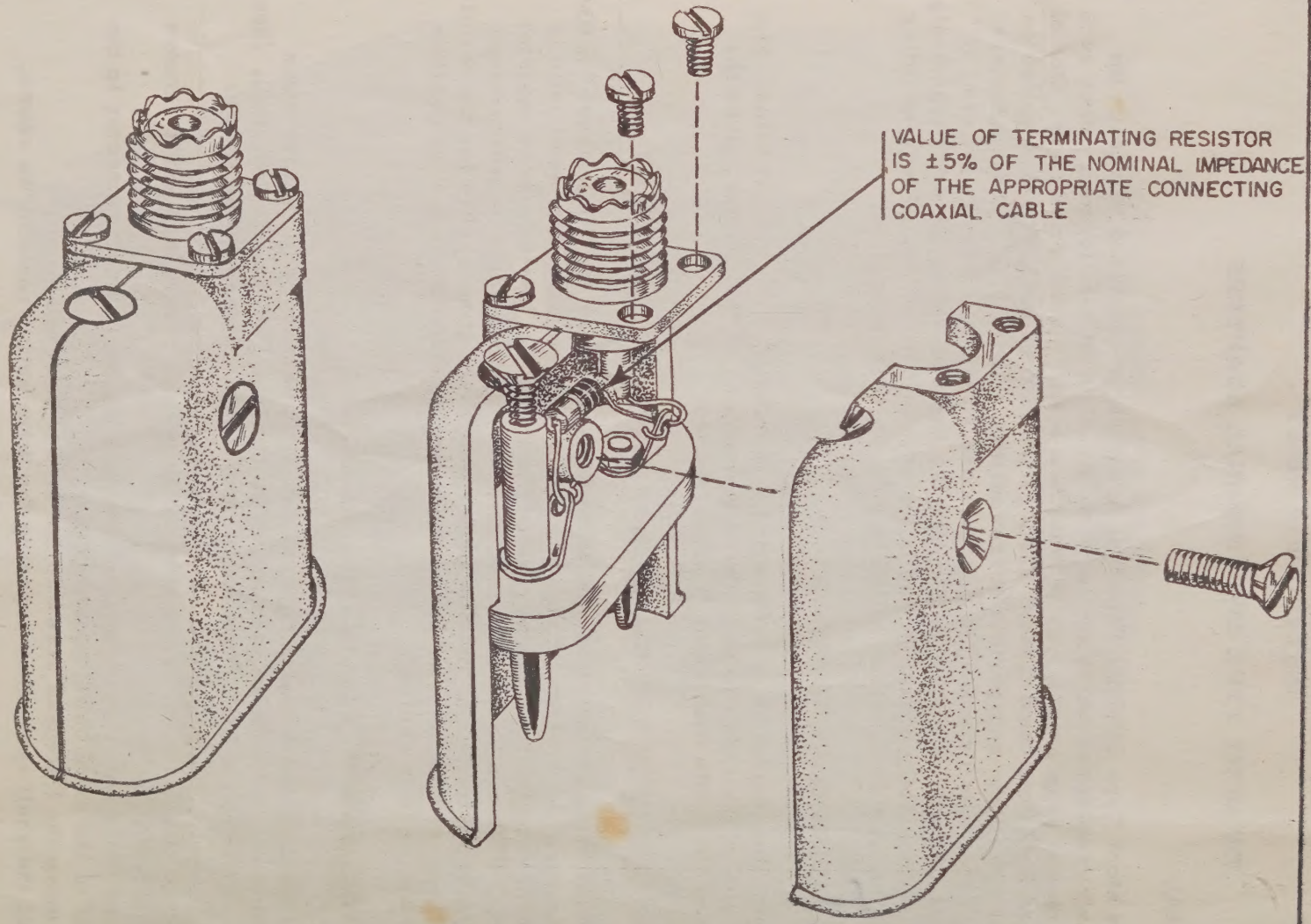

FIGURE 1. DU MONT TYPE 2592-( ) TERMINAL ADAPTER SHOWING METHOD FOR GAINING ACCESS TO TERMINATING RESISTOR

TYPES 411 AND 411-R

OSCILLOSCOPES

PRELIMINARY

OPERATING AND MAINTENANCE MANUAL

Manual 6703 2901 Issue 1

ALLEN B. DU MONT LABORATORIES, INC.
INSTRUMENT DIVISION
760 BLOOMFIELD AVENUE, CLIFTON, NEW JERSEY

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SECTION 1

TECHNICAL SUMMARY

1-1. INTRODUCTION

This manual of operating and maintenance instructions contains information on both the Type 411 (bench model) and Type 411-R (rack mounted) Oscilloscopes. Electrically, the two types are identical; mechanically, they differ only in exterior appearance. These differences are clearly indicated in the text. Otherwise, references throughout the manual to the Type 411 pertain also to the Type 411-R.

1-2. PURPOSE

The Type 411 Oscilloscope is a general purpose dual-beam instrument. It makes possible the viewing of two separate waveforms at the same instant; also, the operator can view an expanded portion of a given waveform simultaneously with the complete waveform.

1-3. FEATURES

- A dual gun mono-accelerator type cathode-ray tube with 2500 volts over-all accelerating potential.
- Two identical calibrated high-gain dc amplifier for driving Channel A and Channel B vertical deflection plates.
- Independent selection by either channel of calibrated high-level sweep, expanded sweep, or external X input signals for driving the horizontal deflection plates.
- Independent selection by either channel of two identical calibrated high-gain dc amplifiers for driving the horizontal and vertical deflection plates.
- Provision for balanced or single-ended vertical input signals.
- Internal calibrating signal.
- Accurate vertical sensitivity controls.
- Variable intensity edge-lit scale for use in photographic recording.

- Suitable color filters to match cathode-ray tube screen characteristics.
- Provision for Z-axis (intensity) modulation.
- Sweep gate output signal for synchronizing associated equipment.
- Provision for direct access to the deflection plates of the cathode-ray tube.

1-4. LIST OF RECOMMENDED ACCESSORIES

Below is a list of Du Mont accessories that can be used with the Type 411 Oscilloscope. Refer to Du Mont's catalog of Components and Accessories for detailed information on specifications and prices. In addition to the items listed below, Du Mont has a complete line of cameras for moving film and single-frame oscilloscopic recording.

Type or Part Number	Description
	FILTERS
4800 4511	Color filter, green
4800 4512	Color filter, blue
4800 4513	Color filter, amber
	PROBES AND TIPS
316	Attenuator Probe
2507	Attenuator Probe
2609	Detector Probe
2613	Attenuator Probe (used with Type 2592-B Terminal Adapter)
3010	Five-inch insulated probe tip which fits Type 2613 Probe
3004 0311	Hook-on tip for Type 2613 Probe
3600 5751	Insulated alligator tip for Type 2613 Probe
5101 6671	Needle-nose tip for Type 2613 Probe

Type of Part Number	Description
TABLES	
2601-A	Movable table, non-adjustable shelf
2602	Movable table, adjustable shelf
TERMINAL ADAPTER	
2592-B	Terminal Adapter, un-terminated, for use with BNC Type connector
VIEWING ACCESSORY	
276-C	Viewing hood

1-5. TECHNICAL SUMMARY

The electrical and physical characteristics of the Types 411 and 411-R are listed in Table 1-1 which follows.

TABLE 1-1

TECHNICAL SUMMARY

DU MONT TYPES 411 AND 411-R OSCILLOSCOPES

CATHODE-RAY TUBE

1-1.	TYPE	5ARP- operated at a nominal accelerating potential of 2500 volts
1-2.	ILLUMINATED SCALE	
	a. Scale	Engraved edge-lit scale and appropriate color filter over face of tube. Dimmer control varies illumination level from zero to intensity adequate for photographic recording
	b. Vertical Scale Division	
	1) Major division	~~0.3 inch;~~ 1 CM. 10 major divisions total ~~3 inches~~ 10 CM. full scale
	2) Minor division	~~0.060 inch;~~ 0.2 CM. located on vertical center line
	c. Horizontal Scale Division	
	1) Major division	1 centimeter; 10 major divisions total 10 centimeters full scale
	2) Minor division	0.2 centimeter; located on horizontal center line

CHANNEL A OR CHANNEL B VERTICAL DEFLECTION AMPLIFIER

2-1.	INPUT COUPLING	
	a. Single-ended	Direct or through capacitor of 1000-volt rating to amplifier; all sensitivity settings
	b. Balanced	Direct only; see 2-2b
	c. Direct to Deflection Plates	Provision is made for direct connection to the deflection plates. For best focus, an average dc potential of 250 volts with respect to ground should be maintained.

TABLE 1-1. TECHNICAL SUMMARY (Contin.)

2-2. INPUT SENSITIVITY RANGE

a. Single-ended Signals

VOLTS PER DIVISION set to AC/DC:	Sensitivity per division with (MULTIPLIER) set to:				
	X.1	X.5	X1	X2	X5
.001	100 uV	500 uV	1 mV	2 mV	5 mV
.01	*	*	10 mV	20 mV	50 mV
.1	*	*	100 mV	200 mV	500 mV
1	*	*	1 volt	2 volts	5 volts
10	*	*	10 volts	20 volts	50 volts

*For optimum bandwidth performance, it is recommended that these sensitivity settings be made in other combinations of input selector controls. For example: where 10 millivolts per division sensitivity is required, set VOLTS PER DIVISION TO .01 and (MULTIPLIER) to X1

1) Maximum grid signal..... 0.5 volt unidirectional; 1 volt peak-to-peak

NOTE: WHEN THE Y-AMPLIFIER IS SWITCHED TO THE X-DEFLECTION PLATES, THE SENSITIVITY OF THE AMPLIFIER IS REDUCED; HENCE, A ONE MILLIVOLT FULL SCALE PATTERN MAY NOT BE OBTAINED.

b. Balanced Signal

VOLTS PER DIVISION set to DC:	Sensitivity per division with (MULTIPLIER) set to:				
	X.1	X.5	X1	X2	X5
.001	100 uV	500 uV	1 mV	2 mV	5 mV
.01	1 mV	5 mV	10 mV	20 mV	50 mV

1) Maximum common mode signal ..... 6 volts peak, less the amplitude of observed signal

2) Maximum grid-to-grid signal ..... 1 volt peak-to-peak

TABLE 1-1. TECHNICAL SUMMARY (Contin.)

2-2. INPUT SENSITIVITY RANGE (Continued)

c. Vertical Calibration

Accuracy ..... Over-all accuracy of ±5% of full scale deflection

NOTE:

Changes in the average horizontal deflection plate voltage (D1 - D2) will cause minor changes in Y deflection sensitivity (D3 - D4). These changes occur as a function of cal sweep positioning. To minimize this effect, all operations requiring precision from the Y amplifier should be performed with the calibrated sweep starting at the left edge of the illuminated scale.

TABLE 1-1. TECHNICAL SUMMARY (Contin.)

2-3. INPUT IMPEDANCE

a. Through Amplifier

1) Single-ended ..... 2 megohms, approximately 60 uuf

2) Balanced..... 4 megohms, approximately 30 uuf

b. Direct to Deflection Plates

1) Single-ended ..... 2 megohms, 10 uuf

2) Balanced..... 4 megohms, 10 uuf

2-4. DEFLECTION SENSITIVITY

a. Through Amplifier at Full Gain..100 microvolts dc or peak-to-peak per ~~division~~ CM.

b. At Deflection Plates .....~~10.5~~ 13.8 volts dc or peak-to-peak, ±10%, per ~~division~~ CM.

2-5. ON-SCREEN DISPLAY

a. Expansion and Positioning..... Any portion of three times full scale deflection can be positioned on screen

b. Linearity..... Any 10% portion of the trace will be within 5% of any other 10% portion of the trace throughout the ten-division full scale limit

c. Undistorted Deflection (varies with sensitivity settings as tabulated below)

VOLTS PER DIVISION set to:	(MULTIPLIER) set to:	Maximum Undistorted Deflection
.001	X.1, X.5, X1 or X2	Undirectional or symmetrical signal: 3 times full scale
.01, .1	X5	Unidirectional signal: full scale Symmetrical signal: twice full scale
1 or 10		

TABLE 1-1. TECHNICAL SUMMARY (Contin.)

2-6.	SINUSOIDAL FREQUENCY RESPONSE (Referred to sensitivity at 1 Kc)		
	a.	High Frequency	
		1) 2 millivolts to 50 volts per division	Less than 30% down at 100 Kc; in 50 millivolt position, (MULTIPLIER) is set to X5
		2) 1, 0.5, and 0.1 millivolts per division	Less than 30% down at 60 Kc
	b.	Low Frequency	
		1) Direct coupled	Flat from dc to specified upper frequency limit
		2) Capacitively coupled	Down not more than 30% at 1 cycle
2-7.	PULSE RESPONSE (to a step function)		
	a.	Rise Time	Less than 3.3 microseconds at all VOLTS PER DIVISION and (MULTIPLIER) settings at or over 50 millivolts; increase to 5 microseconds at maximum sensitivity
	b.	Overshoot	Less than 2%
	c.	Decay at top	
		1) Direct coupled	Less than 2% deflection in 5 seconds
		2) Capacitively coupled	Less than 15% in 50 milliseconds (10 cps square wave)

TABLE 1-1. TECHNICAL SUMMARY (Contin.)

2-8.	AMPLITUDE CALIBRATION	
	a. Availability	To vertical amplifier by setting (MULTIPLIER) to the CAL position (input signal is thus automatically disconnected)
	b. Waveshape and Frequency	Clipped sine wave at power-line frequency
	c. Amplitude	~~0.5~~ 0.25 volt ±2%
	HORIZONTAL DEFLECTION AMPLIFIER	
3-1.	INPUT COUPLING	
	a. Single-ended	Direct or through capacitor of 600-volt rating to amplifier
	b. Direct to Deflection Plates	Provision is made for direct connection to the deflection plates. For best focus, an average dc potential of 250 volts with respect to ground should be maintained
	c. Attenuation	By ratio of 1 or 10 as determined by X SELECTOR switch (external signals only)
3-2.	DISPLAY SYSTEM	An X DISPLAY switch for each channel provides independent selection of high-level calibrated sweep, expanded sweep, external X INPUT signals, and the use of identical amplifiers for driving X and Y deflection plates

TABLE1-1. TECHNICAL SUMMARY (Contin.)

3-3.	INPUT IMPEDANCE	
	a. Through Amplifier	2 megohms, 50 uuf
	b. Direct to Deflection Plates	
	1) Single-ended	2 megohms, 10 uuf
	2) Balanced	4 megohms, 10 uuf
3-4.	DEFLECTION SENSITIVITY	
	a. Through Amplifier at Full Gain	0.3 volt dc or peak-to-peak per centimeter
	b. At Deflection Plates	20 volts dc or peak-to-peak, per centimeter, ±10%
3-5.	ON SCREEN DISPLAY	
	a. Expansion and Positioning	Any portion of the X signal or of the amplified sweep, expanded to five times full scale deflection, can be positioned on the screen
	b. Undistorted Deflection	No on-screen distortion will be noted over the visible portion of the expanded trace; reduced performance at sweep rates of 1 and 2 microseconds per centimeter
	c. Linearity	Any 10% portion of the trace will be within 15% of any other 10% portion of the trace within the ten-centimeter full scale limit; reduced performance at sweep rates of 1 and 2 microseconds per centimeter

TABLE 1-1. TECHNICAL SUMMARY (Contin.)

3-6.	SINUSOIDAL FREQUENCY RESPONSE (Referred to sensitivity at 1 Kc)	
	a. High Frequency.....	Down not more than 30% at 100 kc
	b. Low Frequency	
	1) Direct coupled.....	Flat from dc to specified upper frequency limit
	2) Capacitively coupled.....	Down not more than 30% at 1 cycle
3-7.	BEAM GATE.....	Automatic beam brightening during forward sweep. Beam is not visible during sweep retrace or while sweep is at rest. INTENSITY control overrides blanking for X amplifier use The beam gate may be used to gate the beam on for a time interval determined by the SWEEP RATE and (MULTIPLIER) controls when the X amplifier is being used
	SWEEP CIRCUIT	
4-1.	MODE.....	Driven or recurrent as desired
4-2.	SWEEP WRITING RATE	
	a. Internal	
	1) Calibrated.....	From 1 microsecond to 100 milliseconds per centimeter in six steps with multipliers of 1, 2, 5 and 10

TABLE 1-1. TECHNICAL SUMMARY (Contin.)

	2) Expanded	Continuously variable from 1000 milliseconds to 2 microseconds per centimeter
	3) Accuracy	Within ±5% of product of SWEEP RATE and (MULTIPLIER) dial readings (calibrated sweep only)
b.	External	External capacitors may be connected to extend the slow speed sweep range. See Section 2, Operation for further details
4-3.	SWEEP LENGTH	
a.	Calibrated	10 centimeters; +2 centimeters or -0 centimeter
b.	Expanded	50 centimeters minimum (except at sweep rated of 1 and 2 microseconds/centimeter)
4-4.	SWEEP LINEARITY	
a.	Calibrated	Any 10% portion of the sweep will be within 3% of any other 10% portion of the sweep
b.	Expanded	Any 10% portion of the expanded sweep will be within 15% of any other 10% portion, except for the first half microsecond which will be within 20% of any other portion (up to 2 usec/cm)
4-5.	SWEEP POSITIONING	
a.	Calibrated	Within ±1.5 centimeters of left edge of scale
b.	Expanded	50 centimeters minimum (with independent control of either calibrated or expanded sweep)

TABLE 1-1. TECHNICAL SUMMARY (Contin.)

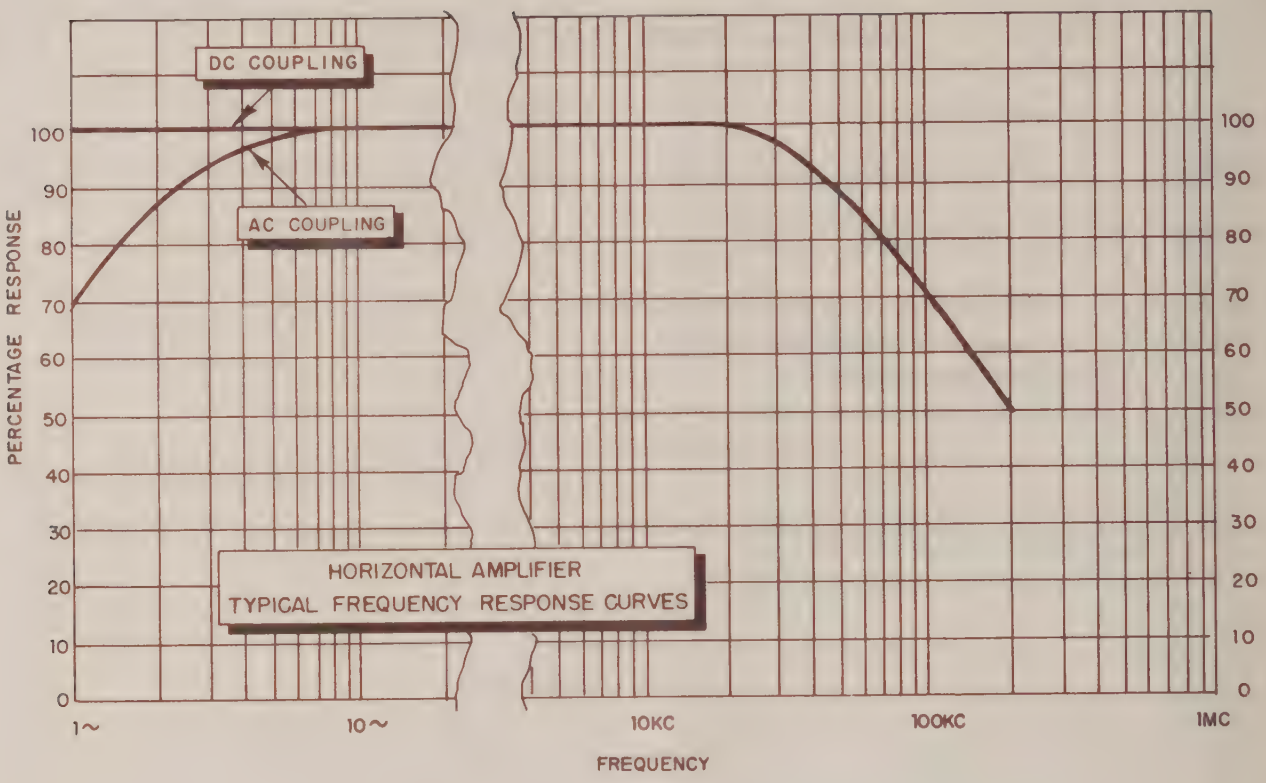
4-6.	BEAM GATE	See 3-7
	SYNC CIRCUIT	
5-1.	SYNCHRONIZATION	
	a. Source	SYNC switch selects: 1. EXTernal 2. Power LINE 3. INTernal, Y-amplifier A 4. INTernal, Y-amplifier B
	b. Polarity	Positive or negative
	c. Sensitivity	
	1) INT	Sweep will synchronize on 1.25 divisions of vertical deflection (minimum)
	2) EXT	Sweep will synchronize on 2 volts peak (minimum)
	d. Signal Type	Sweep can be driven by sine waves from 2 cycles to 100 Kc, and pulses having rate of rise of 20 milliseconds to 23 millimicroseconds per volt; can be synchronized to 500 Kc in the recurrent mode
	e. Sync Output	3.5 volts peak minimum, positive, and capacitively coupled to POS SYNC OUT terminal
5-2.	SWEEP STARTING TIME	
	a. INT	Less than 1.5 microseconds (time between 10% point on rise of sync pulse to 75% point on rise of sweep gate)
	b. EXT	Less than 1 microsecond

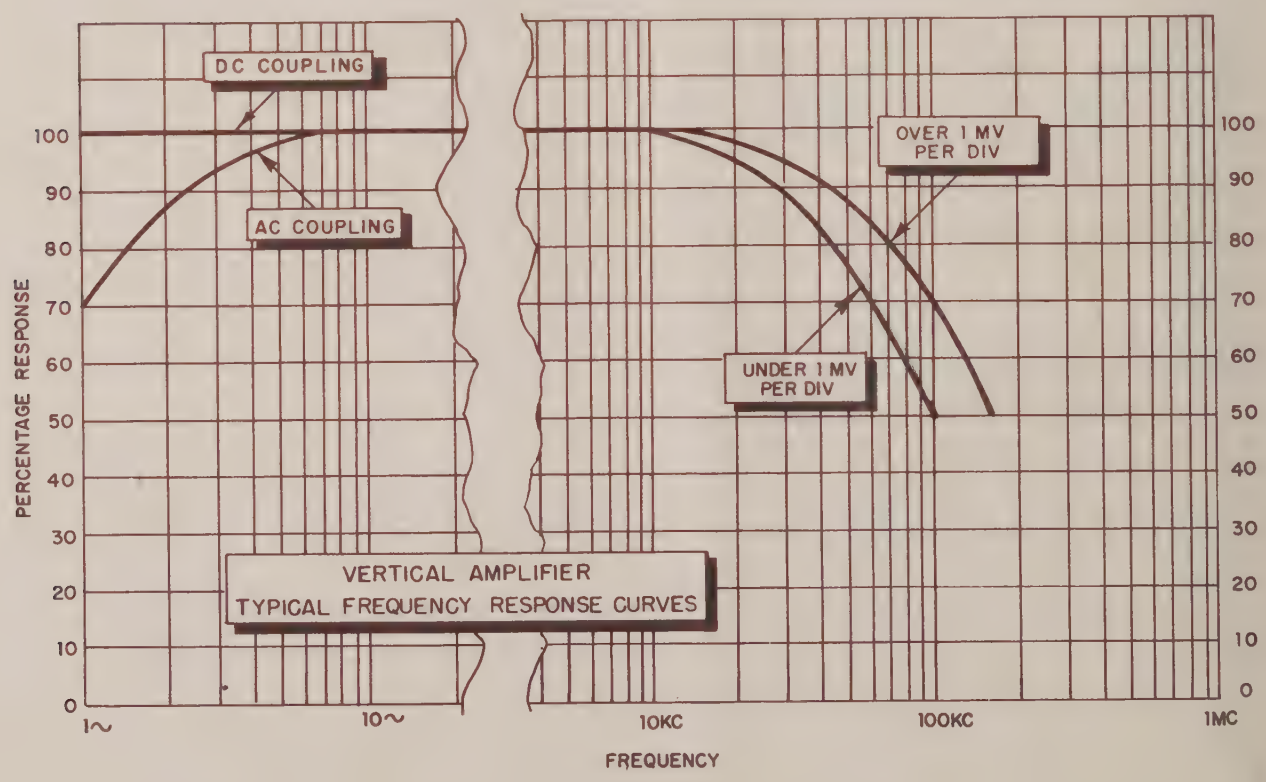
TABLE 1-1. TECHNICAL SUMMARY (Contin.)

		INTENSITY MODULATION CIRCUIT	
6-1.	Z AXIS		
	a.	Availability	Z INPUT terminal is provided on rear panel for signal input
	b.	Input Impedance	39K ohms, 10 uuf
	c.	Frequency Response	30% down at 250 cycles and 10 megacycles
	d.	Polarity and Sensitivity	Positive signals decrease beam intensity; 2 to 56 volts peak, depending on INTENSITY setting, will blank the beam
		POWER SUPPLY	
7-1.	PRIMARY POWER REQUIREMENTS		
	a.	Line Voltage	115/230 volts, ±10% single phase
	b.	Line Frequency	50 to 400 cycles
	c.	Power	Approximately 270 watts, 310 VA at nominal line
7-2.	HIGH-VOLTAGE SUPPLY		
	a.	Type	An electronically regulated rf supply system for generating CRT accelerating potential is provided
	b.	Regulation	±2% over range of INTENSITY control

TABLE 1-1. TECHNICAL SUMMARY (Contin.)

PHYSICAL CHARACTERISTICS		
	Type 411	Type 411-R
Height	17-1/2 inches (44.45 cm)	17-1/2 inches (44.45 cm)
Width	13-1/2 inches (34.29 cm)	19 inches (48.26 cm)
Depth	23-1/4 inches (59.05 cm) includes bezel and power cable support	21 inches (53.34 cm) (behind panel)
	Approximately 70 pounds (31.751 Kg)	


DC COUPLING
AC COUPLING
HORIZONTAL AMPLIFIER
TYPICAL FREQUENCY RESPONSE CURVES
PERCENTAGE RESPONSE
100
90
80
70
60
50
40
30
20
10
0
1~
10~
10KC
100KC
1MC
FREQUENCY


DC COUPLING
AC COUPLING
OVER 1 MV PER DIV
UNDER 1 MV PER DIV
VERTICAL AMPLIFIER
TYPICAL FREQUENCY RESPONSE CURVES
PERCENTAGE RESPONSE
100
90
80
70
60
50
40
30
20
10
0
1~
10~
10KC
100KC
1MC
FREQUENCY

SECTION 2

OPERATION

2-1. GENERAL

The Du Mont Types 411 and 411-R Oscilloscopes are shipped with all tubes in place and ready to operate. Since these instruments are portable, no special installation procedure is required. The -R model is adapted for mounting the instrument in a standard relay rack or cabinet.

Normally this instrument may be placed where most convenient for viewing while at the same time maintaining short signal leads. Although shielding has been provided, operation in very strong magnetic fields may cause spurious deflections and should be avoided. Reorientation or additional shielding of the instrument may be necessary to minimize the effects of such field.

Two tracking adjustments (DP CORR) are provided to superimpose the cathode-ray tube's two beams in the horizontal plane. These adjustments are set at the factory with great care. However, the electron beams are affected to a slight degree by the earth's magnetic field. Hence, a slight change in tracking may be noted as the instrument is moved through azimuth or elevation. For this reason, the DP CORR adjustments are accessible to the operator at the rear of the instrument and may be readjusted when desired. Adjustment procedure is given in Table 4-2, Service Adjustment Chart.

The instrument is intended for operation from a 50-400 cycle, single-phase, 115/230 - volt power source and will operate satisfactorily with line-voltage variations of $\pm 10\%$. Where line-voltage variations are excessive, and where extreme stability is required, it is suggested that a constant-voltage transformer of suitable power rating be employed in the power line to the instrument.

NOTE: Since the power supplies of this instrument are the capacitor-input type, relatively large peak currents are required from the primary mains. Hence, when using primary power from any other source, the generator employed must be capable of supplying these peak currents.

2-2. FRONT AND REAR-PANEL FACILITIES (TABLE 2-1)

The front and rear-panel markings are essentially self explanatory, and after carefully studying Table 2-1, the operator will find it possible to master the controls with a minimum of practice.

TABLE 2-1

FRONT AND REAR-PANEL FACILITIES

NAME	FUNCTION
CHANNEL A OR B FRONT-PANEL FACILITIES	
INTENSITY	Control: varies the trace brightness
FOCUS	Control: adjusts the trace sharpness
X DISPLAY	Switch: provides selection of calibrated sweep, expanded sweep, external X INPUT signals, and external Y INPUT signals of the adjacent channel for the horizontal deflection: extinguishes the trace in the BEAM OFF position
	Concentric controls:
VOLTS PER DIVISION	a. Outer knob provides for the direct reading of the input signal in volts per division for both capacitive or direct inputs when vertical amplifier is properly calibrated; it grounds the input stage of the vertical amplifier in the OFF position
(MULTIPLIER)	b. Inner knob multiplies VOLTS PER DIVISION settings by factors of 0.1, 0.5, 1, 2, or 5; connects calibrator signal to vertical amplifier in CAL position; facilitates Y MULT BAL adjustment in the BAL position
Y AMPLITUDE	Control with switch: provides continuous amplitude variation of vertical deflection (switch not actuated); when set fully clockwise, (CAL), switch is actuated, Y AMPLITUDE control is inoperative, and the instrument can be set for vertical deflection
Y CAL ADJ	Screwdriver control: sets the gain of the vertical amplifier to provide the specified volts per division deflection with the CAL signal applied. This is only operative when Y AMPLITUDE is set fully clockwise. See paragraph 2-7b

TABLE 2-1. FRONT AND REAR-PANEL FACILITIES (Contin.)

NAME	FUNCTION
Y POSITION	Control: positions the trace vertically
Y MULT BAL	Screwdriver control: when properly adjusted, prevents vertical movement of the trace when switching through the VOLTS PER DIVISION and (MULTIPLIER) ranges. See paragraph 2-7a
Y INPUT	Binding posts: connections for external signals to the vertical amplifier, either balanced or single-ended
Y AMPLITUDE DC BAL (left and right side of cabinet)	Screwdriver control: when properly adjusted, prevents vertical movement of the trace when the Y AMPLITUDE control is varied. See paragraph 2-7a
SYNC AND SWEEP FRONT-PANEL FACILITIES	
	Concentric controls:
SWEEP RATE	a. Outer knob provides adjustment of sweep writing rates from 1 microsecond to 100 milliseconds per centimeter in six steps. Provision for extending the low sweep rate is given in paragraph 2-5f
(MULTIPLIER)	b. Inner knob multiplies SWEEP RATE settings by factors 1, 2, 5, and 10; VER position inserts SWEEP VERNIER control which enables continuous variation of sweep writing rates over a 10:1 range
SYNC (SELECTOR)	Control: selects source of sweep synchronizing signals (EXT, LINE, INT A, and INT B)
(SYNC) LEVEL	Control: selects polarity and adjusts the amplitude of sweep synchronizing signals
SWEEP VERNIER	Control: provides a 10:1 continuous variation of sweep writing rates within the limits established by the SWEEP RATE control when (MULTIPLIER) is set to VER

TABLE 2-1. FRONT AND REAR-PANEL FACILITIES (Contin.)

NAME	FUNCTION
SYNC IN	Binding posts: provides for connection of external synchronizing signals to the EXT position of the SYNC (SELECTOR) switch
POS SYNC OUT	Binding posts: provides positive signals coincident with the start of the sweep to enable synchronization of auxiliary equipment
SWEEP CALIBRATE (right side of cabinet)	Screwdriver control: an adjustment for over-all sweep calibration. See paragraph 2-5b
X AMPLIFIER AND OTHER FRONT-PANEL FACILITIES	
POWER	Toggle switch: provides a means for turning the instrument on or off
SCALE	Control: varies the illumination level of the scale to facilitate photographic recording
X SELECTOR	Concentric controls a. Outer knob selects internal SWP or external X INPUT signals for the horizontal deflection In SWP position, the internal sweep is coupled to the X amplifier and the expanded sweep output is applied to the X deflection plates when X DISPLAY is set to EXP SWP For external signals, either ac of dc coupling at attenuation ratios of 1 or 10 is provided; the X AMPLIFIER output is applied to the X deflection plates when X DISPLAY is set to X AMP
STABILITY	b. Inner knob provides adjustment for either driven or recurrent sweep operation. See paragraphs 2-5d and 2-5e
CAL SWP POS	Control: enables start of calibrated sweep to be positioned horizontally within ±1.5 centimeters of left edge of scale

TABLE 2-1. FRONT AND REAR-PANEL FACILITIES (Contin.)

NAME	FUNCTION
EXP SWP POS	Control: positions the expanded sweep trace or signals applied to X INPUT horizontally. This control is independent of the CAP SWP POS control
X AMPLITUDE	Control: provides continuous 20:1 amplitude adjustment of horizontal deflection when X SELECTOR is set to AMPLIFIER or expanded SWP
X INPUT	Binding posts: connections for external signals to the horizontal amplifier when X SELECTOR is set to AMPLIFIER
MODE RANGE (right side of cabinet)	Screwdriver control: used in conjunction with the STABILITY control for adjustment of driven or recurrent sweep operation. See paragraph 2-5c
CHANNEL A OR B REAR-PANEL FACILITIES (Accessible at Rear of Cabinet or Dust Cover)	
*D1 (right and D2 (left)	Terminal lugs: provides direct connection of signals to the horizontal deflection plates
*D3 (down) and D4 (up)	Terminal lugs: provides direct connection of signals to the vertical deflection plates
Z INPUT	Terminals lugs: provides connection of external signals for intensity modulation of the trace
The following controls do not require adjustment during normal operation. If adjustment is required, see the Service Adjustment Chart in the Maintenance Section of this Manual.	
-HV ADJ	Screwdriver control: establishes the proper high voltage output for application to the cathode-ray tube
*Data in ( ) indicates the direction of deflection on CRT screen resulting from the application of a positive signal	

TABLE 2-1. FRONT AND REAR PANEL FACILITIES (Contin.)

NAME	FUNCTION
DP CORR	Screwdriver control: compensates for differences in geometric spot center of the two guns; also compensates for the slight change in X tracking, due to the effect of the earth's magnetic field, as the instrument is move through azimuth or elevation
ASTIG & PRE-accel	Screwdriver control: establishes the proper voltages at cathode-ray tube's electrodes to minimize beam distortion

2-3. PRECAUTION AGAINST SCREEN BURNING

A sharply focused spot of high intensity and small area should not be permitted to remain stationary on the screen for any length of time. Under such conditions, the entire beam energy is concentrated over a small area, thus subjecting the screen material to burning and discoloration. This condition is most likely to exist when using the driven mode of sweep operation, with the INTENSITY turned up, and no signal input.

2-4. ENERGIZING THE EQUIPMENT

To place the instrument in operation, plug the power cord into the proper power source and turn on the POWER switch. Allow approximately 15 minutes for the instrument to warm up.

2-5. OPERATING HINTS FOR THE SWEEP CIRCUIT

a. INTERPRETATION OF SWEEP CONTROL SETTINGS (TABLE 2-2)

The calibrated sweep writing rate in milliseconds or microseconds per centimeter is equal to the product of the SWEEP RATE and (MULTIPLIER) controls only when the X DISPLAY switch is set to CAL SWEEP. Table 2-2 lists the control settings for calibrated sweep operation.

There are separate horizontal positioning controls for calibrated sweep and expanded sweep operation. When the instrument is set for calibrated sweep, the CAL SWP POS is used to position the trace horizontally. If the instrument is set up for expanded sweep or X-amplifier operation, the EXP SWP POS control is used to position the trace horizontally.

When the (MULTIPLIER) control is in the VER position, the sweep rate is continuously variable over a 10:1 (uncalibrated) range. Sweep expansion is obtained by setting the X DISPLAY switch to X AMP/EXP SWP and adjusting the X AMPLITUDE for the desired expansion. Under these conditions, use of the EXP SWP POS control enables any portion of the expanded sweep to be displayed on the screen.

TABLE 2-2

CALIBRATED SWEEP WRITING RATES

SWEEP RATE set to	(MULTIPLIER) set to X1	X2	X5	X10
	Sweep rate in milliseconds per centimeter			
100 MS/CM	100	200	500	1000
10 MS/CM	10	20	50	100
1 MS/CM	1	2	5	10
	Sweep rate in microseconds per centimeter			
100 uS/CM	100	200	500	1000
10 uS/CM	10	20	50	100
1 uS/CM	1	2	5	10

b. SWEEP CALIBRATION PROCEDURE

(1) USING 50, 60-CYCLE LINE FREQUENCY

Over-all sweep calibration at the power-line frequency will normally provide a sufficiently high degree of accuracy. This is because the power-line frequency is generally held accurate to 0.5%, comparable to a finely focused spot on the screen.

The complete sweep calibration procedure is given in Maintenance, Table 4-2. However, reference to this procedure should be resorted to only if the instrument cannot be calibrated properly by means of the SWEEP CALIBRATE adjustment (right side of cabinet). When checking sweep calibration, refer to the instructions which follow:

1) Allow a minimum warmup time of 15 minutes.

2) Set (MULTIPLIER) to CAL and X DISPLAY to CAL SWP.

3) Set SWEEP RATE to 10 MS/CM and (MULTIPLIER) to X1.

4) Set SYNC (SELECTOR) to INT and adjust STABILITY for a stable pattern.

5) If necessary, set the SWEEP DURATION (see Table 4-2) to give a minimum deflection of 10.5 centimeters.

6) For a 60-cycle line, adjust SWEEP CALIBRATE until 6 cycles of the calibration signal appear precisely in ten centimeters. All ranges will then be within the specified tolerance.

7) For a 50-cycle line, adjust SWEEP CALIBRATE until 5 cycles of the calibration signal appear precisely in ten centimeters.

(2) USING OTHER CALIBRATION FREQUENCIES (TABLE 2-3)

Table 2-3 lists control settings and frequencies, under which conditions, exactly 10 cycles of the applied signal appear in precisely ten centimeters. To facilitate sweep calibration, it is suggested that the applied signal be limited to frequencies between 10 cycles and 200 kilocycles. Above 200 kilocycles, synchronization difficulties may occur. Below 10 cycles, trace flickering may interfere with the calibration procedure.

TABLE 2-3

TABLE OF CALIBRATION FREQUENCIES

SWEEP RATE set to	Frequency required with (MULTIPLIER) set to			
	X1	X2	X5	X10
100 MS/CM	10 cps	--	--	--
10 MS/CM	100	50 cps	20 cps	10 cps
1 MS/CM	1 Kc	500 cps	200 cps	100 cps
100 uS/CM	10 Kc	5 Kc	2 Kc	1 Kc
10 uS/CM	100 Kc	50 Kc	20 Kc	10 Kc
1 uS/CM	--	--	200 Kc	100 Kc

PROCEDURE

1) Allow a minimum warm-up time of 15 minutes.

2) Set X DISPLAY to CAL SWP.

3) Set SYNC (SELECTOR) to INT and adjust for a stable pattern.

4) Apply the desired frequency to Y INPUT in accordance with the SWEEP RATE and (MULTIPLIER) settings.

5) Adjust SWEEP CALIBRATE until 10 cycles of the applied signal appear precisely in ten centimeters.

c. MODE RANGE ADJUSTMENT

Set the MODE RANGE adjustment (right side of cabinet) so that the STABILITY control range is centered. This range is established by: (1) the point where synchronized driven sweep is cut off; and (2) at the threshold of recurrent sweep with no sync. Variation of this setting, caused by drift and component aging, should be limited so that recurrent sweep is obtained when the STABILITY controls is turned not less than 15° away from its fully clockwise position.

d. DRIVEN SWEEP (TABLE 2-4)

Refer to Table 1-1, Technical Summary for information on sync sensitivities, and to Table 2-1 for information on panel controls.

A stable pattern for practically all types of signals can be obtained by using driven sweep; its use is mandatory for viewing random or non-periodic signals or periodic signals of low duty cycle. When operating the instrument in this manner, one sweep occurs for each signal impulse. Use of the driven sweep mode of operation, in the majority of applications, is the condition under which optimum performance can be expected of this equipment.

When the instrument is set for driven sweep, the spot will be visible only during forward sweep time, provided the INTENSITY control is not set too far clockwise.

Table 2-4 lists the control settings and adjustment procedures for driven sweep operation.

TABLE 2-4

DRIVEN SWEEP OPERATION

CONTROL	SETTING
INTENSITY & FOCUS	Approximately 1/3 CW
VOLTS PER DIVISION & (MULTIPLIER)	Set as determined by amplitude of signal source
X SELECTOR & X DISPLAY	Set as determined by the type of horizontal display desired
SYNC (SELECTOR)	Set as determined by signal source
(SYNC) LEVEL	"O" (no sync)
Y POSITION	Center of range
CAL SWP POS & EXP SWP POS	Center of range

PROCEDURE
1) Apply the desired signal to Y INPUT
2) Rotate STABILITY clockwise to just below the threshold of free-running sweep
3) Set (SYNC) LEVEL to fully plus or to fully minus rotation. Intermediate settings are used only when it is desired to trigger from some signal level other than zero
4) Set SWEEP RATE and (MULTIPLIER) controls to obtain the desired number of cycles on screen
5) Adjust INTENSITY and FOCUS controls to obtain a sharp trace of suitable brightness level
6) If necessary, make slight corrections of the STABILITY control setting to achieve optimum stability

e. RECURRENT SWEEP

In some applications it is desirable to have the sweep free-running, whether synchronized or not. To achieve this condition proceed as follows: set up the controls as indicated in Table 2-4, except that the STABILITY control is adjusted until the sweep operates continuously.

One advantage of this mode of operation, is the ability of the sweep to be synchronized to high-frequency repetitive functions beyond that of driven sweep operation. Another advantage is the display of non-synchronous waveforms.

f. EXTENSION OF LOW SWEEP RATES (FIGURE 2-1)

Provision is made for connecting external capacitors to obtain lower sweep writing rates than provided for in the instrument. For lower speed rates, proceed as follows:

> CAUTION
>
> **The external capacitor terminals (right side of cabinet) are approximately 120 volts above ground**

Turn off the power and set SWEEP RATE to 100 MS/CM and (MULTIPLIER) to X10. Connect the capacitor to the terminals provided. The sweep rate is given by the following formula:

$$T = \frac{C + 2}{2}$$

Where: T = sweep rate in seconds per centimeter
C = additional shunt capacitance in microfarads

This formula is shown graphically in Figure 2-1.

A high-leakage resistance capacitor (in excess of 100 megohms) of the highest possible quality such as Sprague's Styracon B is recommended. Ordinary paper capacitors have high temperature coefficients and poor recovery characteristics. The results will depend entirely on the quality of the component. Tolerance of the external capacitor should be $\pm 1\%$ to maintain calibration.

g. POSITIVE SYNC OUTPUT

A portion of the sweep unblanking gate is picked off and coupled by a blocking capacitor to the front panel terminals marked

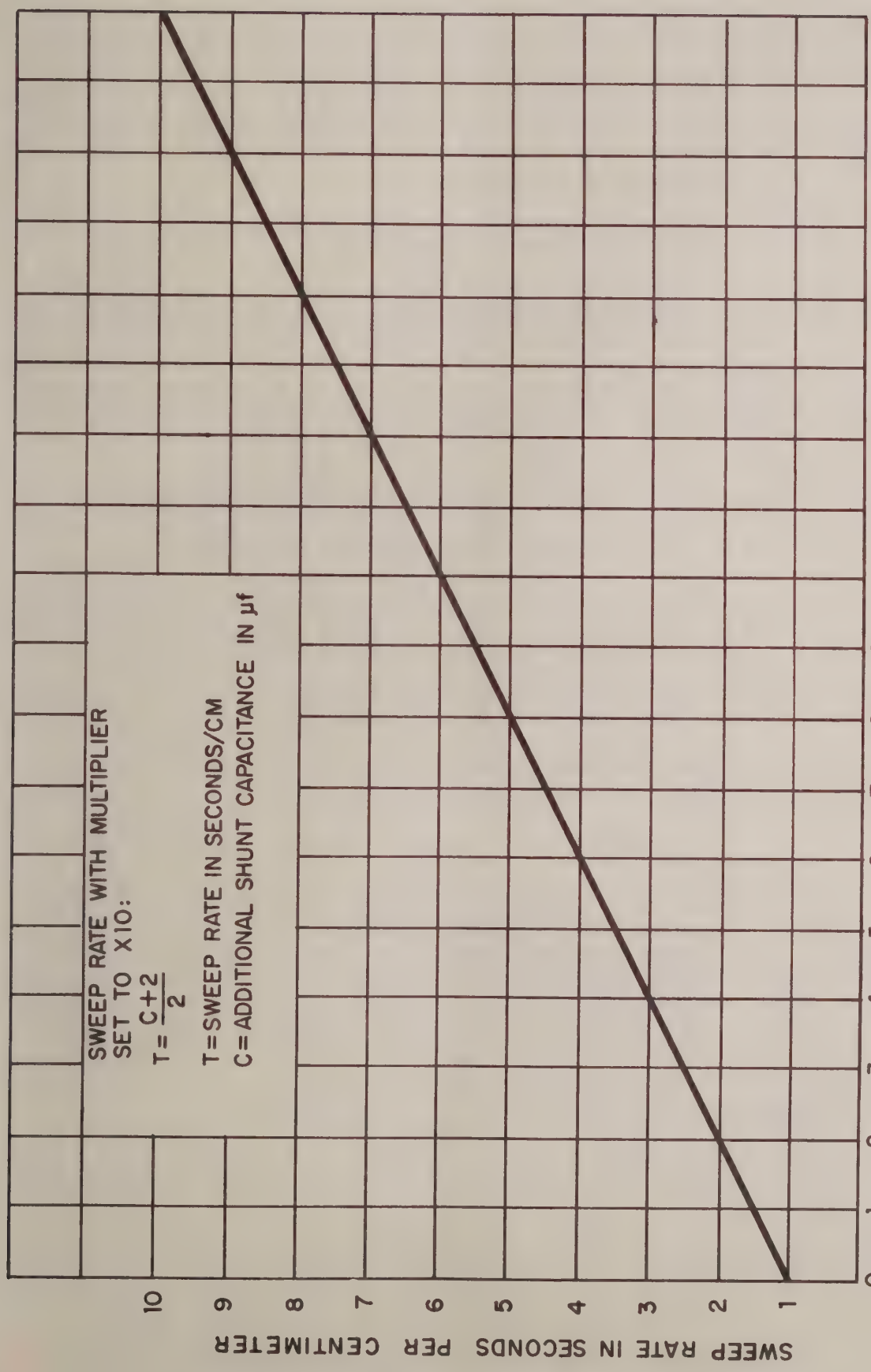

SWEEP RATE WITH MULTIPLIER SET TO X10:
T = C+2 / 2
T=SWEEP RATE IN SECONDS/CM
C=ADDITIONAL SHUNT CAPACITANCE IN µf
SWEEP RATE IN SECONDS PER CENTIMETER
ADDITIONAL CAPACITY IN µf
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
1 2 3 4 5 6 7 8 9 10

FIGURE 2-1. ADDITIONAL CAPACITANCE VERSUS SWEEP RATE

POS SYNC OUT. The signal appears as a positive pulse and is coincident with the start of the sweep to enable synchronization of auxiliary equipment. Note: At the lower sweep rates, the POS SYNC OUT signal is differentiated by the blocking capacitor and load resistor. Thus, a positive signal coincident with the start of the sweep and a negative signal coincident with the end of the sweep are available.

h. SYNC FROM COMPOSITE VIDEO SIGNALS

To facilitate synchronization of the sweep at field rates from a composite television signal, proceed as follows: Set up the controls as indicated in Table 2-4 except that SYNC (SELECTOR) is set to EXT. Connect a 100K-ohm resistor between the Y INPUT and SYNC IN terminals. This resistor, together with the stray capacitances will integrate the vertical serrated pulses when the composite signal is applied to Y INPUT.

2-6. OPERATING HINTS FOR THE HORIZONTAL AMPLIFIER

a. X BAL SERVICE ADJUSTMENT

When the X BAL adjustment is properly set, there will will be no position change of the trace, when the X AMPLITUDE is varied. Normally, this service adjustment will not require resetting. If adjustment is required, refer to Table 4-2 in the Maintenance Section of this manual.

b. INTERPRETATION OF X SELECTOR AND X DISPLAY SETTINGS (Figure 2-2)

(1) IDENTICAL X AND Y AMPLIFIER OPERATION

When Channel A X DISPLAY is set to Y AMP B, the output from Channel B amplifier is applied to Channel A horizontal deflection plates (in addition to being applied to Channel B vertical deflection plates). In other words, Channel B facilities are now primarily used to control the signal applied to Channel A horizontal deflection plates. The converse of this feature is when Channel B X DISPLAY switch is set to Y AMP A.

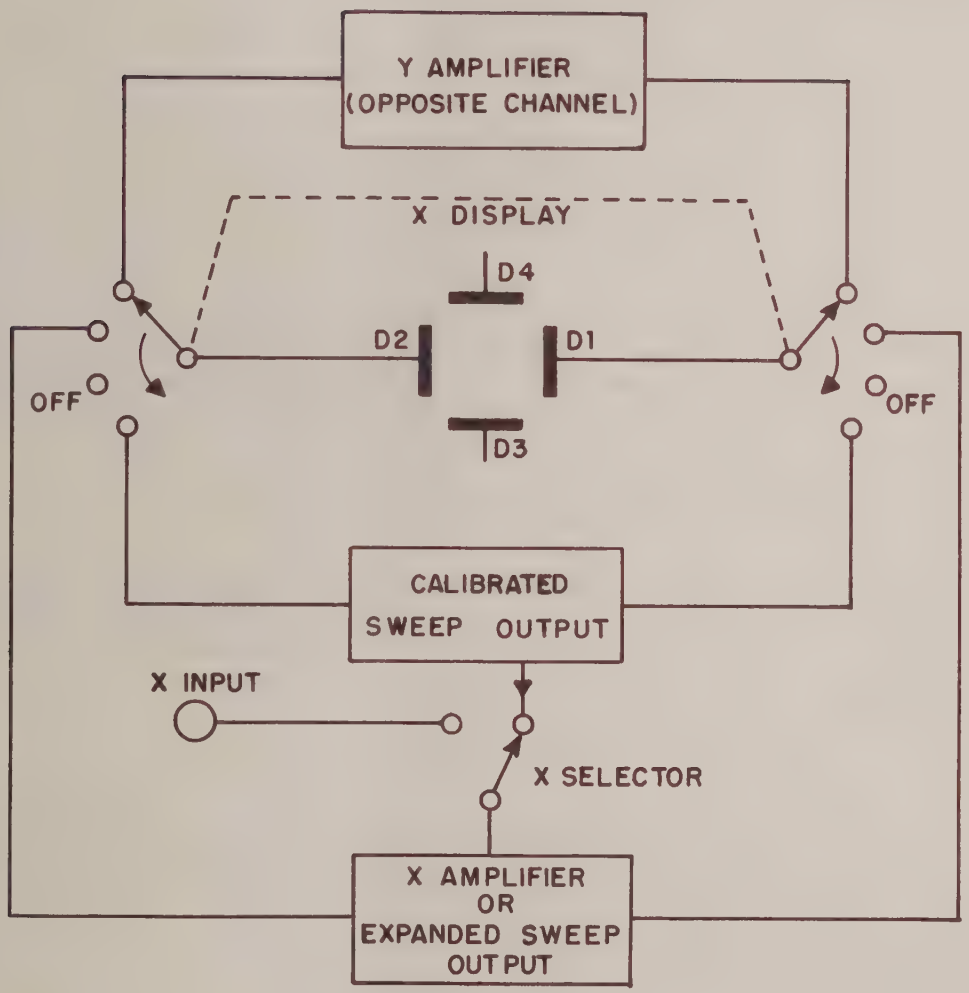


FIGURE 2-2. A OR B X DISPLAY SYSTEM

(2) X AMPLIFIER OR EXPANDED SWEEP OPERATION

In X AMP/EXP SWP position either the X amplifier output or the internal expanded sweep depending on the setting of X SELECTOR is applied independently to the horizontal deflection plates.

For those applications where it is desirable to apply external single-ended signals through the horizontal amplifier, proceed as follows: Set X SELECTOR to AMPLIFIER, AC or DC, and apply the signal to the X INPUT terminals. When the X SELECTOR switch is in the AMPLIFIER positions, the internal sweep is disconnected and the X INPUT terminals are connected to the horizontal amplifier. Attenuation of signals by ratios of 1 or 10 may be obtained.

The over-all gain of the horizontal deflection amplifier is varied by the X AMPLITUDE control. The range of this control is such that it provides expanded sweep up to five times full scale (50 centimeters), and/or a 20:1 control for external signals.

(3) BEAM OFF POSITION

Either beam of the cathode-ray tube can be extinguished independently, by setting the X DISPLAY to BEAM OFF. The corresponding channel indicator lamp will also be turned off and will be lit in all other positions.

(4) CALIBRATED SWEEP POSITION

In the CAL SWP position, the internal high-level calibrated sweep, per SWEEP RATE and (MULTIPLIER) settings, is applied independently to the horizontal deflection plates. Calibrated sweep operation is discussed elsewhere in this Section.

c. X AMPLIFIER GATED BEAM OPERATION

When the X SELECTOR is set for external signals, the sweep circuit is not disabled unless the STABILITY control is fully counterclockwise. Thus, it is possible to trigger the sweep, while viewing external signals, to superimpose the brightening gate on the trace. The duration of this gate may be adjusted by the SWEEP RATE and (MULTIPLIER) controls.

2-7. OPERATING HINTS FOR THE VERTICAL AMPLIFIER

a. BALANCING PROCEDURE

(1) Y MULT BAL

When this control is properly adjusted, there will be no vertical shifting of the trace when switching through the ranges of the VOLTS PER DIVISION and (MULTIPLIER) controls.
Adjustment is as follows:

1) Refer to Table 4-2, Service Adjustment Chart, and check out the GRID CURRENT ADJ.

2) Set the(MULTIPLIER) to BAL and center the trace with Y POSITION control.

3) Set (MULTIPLIER) to X.1 and recenter the trace with the Y MULT BAL control.

4) If necessary, repeat steps 2 and 3 until no vertical displacement of the trace is observed while switching the VOLTS PER DIVISION and (MULTIPLIER) controls throughout their ranges. Note that when the (MULTIPLIER) is switched between the X.1 and X.5 position, a dc shifts occurs which cannot be balanced out. An explanation of why dc shifting occurs only on this range and cannot be balanced out is described in Section 3, Theory of Operation.

(2) Y AMPLITUDE DC BAL

Center the trace with the X and Y POSITION controls. If the trace moves up and down as the Y AMPLITUDE is ro-

tated, the Y AMPLITUDE DC BAL should be adjusted as follows:

1) Make sure the Y MULT BAL control is checked out as given in paragraph (1).

2) Set (Multiplier) to BAL.

3) Set Y AMPLITUDE clockwise to a point just short of actuating the switch.

4) Center the trace with Y POSITION control.

5) Rotate Y AMPLITUDE fully counterclockwise and recenter the trace with the Y AMPLITUDE DC BAL control.

6) If necessary, repeat steps 3 through 5 until no change in vertical displacement of the trace is observed while varying Y AMPLITUDE throughout its range.

NOTE: If Y MULT BAL is readjusted, the Y AMPLITUDE DC BAL may also need readjustment.

b. Y CALIBRATION

Amplitude measurement of the vertical signal may be made by use of the built-in voltage calibrator. The calibrator signal is available internally, and may be substituted for the vertical signal as follows:

1) Set (MULTIPLIER) to CAL and Y AMPLITUDE fully clockwise (switch is actuated).

2) Set Y CAL ADJ to give EXACTLY HALF ~~full~~ scale deflection (5 CM. ~~10 divisions~~). Do not touch this adjustment after it has been set up for amplitude measurement; if moved, repeat step 2.

3) Remove the calibrator pattern by setting the (MULTIPLIER) to X.1, X.5, X1, X2 or X5 position as determined by the amplitude of the signal source.

The vertical amplifier now functions as a voltmeter having a major scale division sensitivity determined by the VOLTS PER DIVISION and (MULTIPLIER) control settings.

c. Y INPUT

(1) SINGLE-ENDED INPUT

Signals to be observed are connected to the vertical channel through the Y INPUT terminal and ground. The VOLTS PER DIVISION switch permits capacitive or direct coupling of the signal to the compensated attenuator. The terminals for direct connection to the deflection plates are accessible at the rear of the cabinet. (See paragraph 2-8 for details.)

(2) USE OF BALANCED INPUT

For balanced input, remove the link from the normally grounded Y INPUT terminal. The VOLTS PER DIVISION switch must be set to the .001 or .01 DC position. Refer to Table 1-1, Technical Summary, for information on limits of common mode signal.

One of the features of the balanced-input circuit is the differential action of the amplifier. This circuit makes it possible to reject to a considerable degree any common-mode signal, while at the same time passing and amplifying the differential input signal. Thus, if there is any pickup of noise on test leads or in the equipment under test, such noise will be reduced materially on passing through the balanced-input amplifier circuit.

2-8. DIRECT CONNECTION TO DEFLECTION PLATES

a. GENERAL

When applying signals to deflection plates, the highest-frequency signal that can be observed is no longer limited by the response of the built-in amplifiers but is dependent upon the input capacitance to the deflection plate terminals and/or transit time of the electrons between the deflection plates. When the impedance of the signal source is low, transit time is only consideration. It should be remembered, however, that

no amplification or attenuation is provided on direct input. See Table 1-1 for deflection sensitivities.

b. MAKING PROPER CONNECTIONS

> CAUTION
>
> Before making connections, shut off power

Direct connection to the deflection plates is made as follows:

1) Disconnect the appropriate deflection plate links from their terminals (rear of cabinet).

2) Apply the signal to D1 and D2 for direct horizontal input; to D3 and D4 for direct vertical input.

3) To avoid any possibility of cross-coupling effects, the VOLTS PER DIVISION and/or X SELECTOR should be switched to OFF.

NOTE: For best focus, an average dc potential of 250 volts above ground must be preserved on both pairs of deflection plates. To preserve this average dc potential when the source impedance is doubtful, it is recommended that blocking capacitors be inserted in series with each signal lead before direct connection is made. These capacitors will (1) minimize the effect of the dc deflection plate voltages on the driving source and (2) minimize the effect of the driving source impedance on the positioning voltage.

c. USING CHANNEL A OR B Y AMPLIFIER AS AN OPERATIONAL AMPLIFIER

The Type 411 Y Amplifier may be used as an operational amplifier for driving many types of transducers. Use of the instrument in this manner is very simple. Merely apply the desired signal to be amplified to Y INPUT. The amplified output signal is taken from D3 and D4 terminals and is applied to the electrical device to be driven. The source impedance of the driven device should be high to maintain optimum bandwidth

performance and amplifier gain. The voltage gain per ~~division~~ CM. of the amplifier is equal to:

$$\frac{E_{out}}{E_{in}} = \frac{13.8 \text{ ~~10.5~~ volts}}{\text{VOLTS PER ~~DIVISION~~ CM. times (MULTIPLIER) setting}}, \pm 10\%$$

2-9. MAKING RISE TIME MEASUREMENTS

Application of signals from an external time calibrator will facilitate pulse rise-time measurements. When making such measurements, the one factor which must be borne in mind for most accurate quantitative results is the pulse response characteristic of the vertical amplifier. This characteristic is related to the observed pulse rise time and the actual pulse rise time in the following manner:

$$t_p = \sqrt{(t_o)^2 - (t_a)^2}$$

Where: t_p = actual pulse rise time in microseconds
t_o = observed rise time of pulse in microseconds
t_a = amplifier rise time in microseconds

Once the amplifier rise time is known (see Table 1-1), the rise time of any pulse may be calculated.

2-10. INTENSITY MODULATION

Refer to Table 1-1, Technical Summary, for intensity modulation data. For intensity modulation of the trace, shut off the power and apply the signal between the Z INPUT terminal (rear panel) and ground.

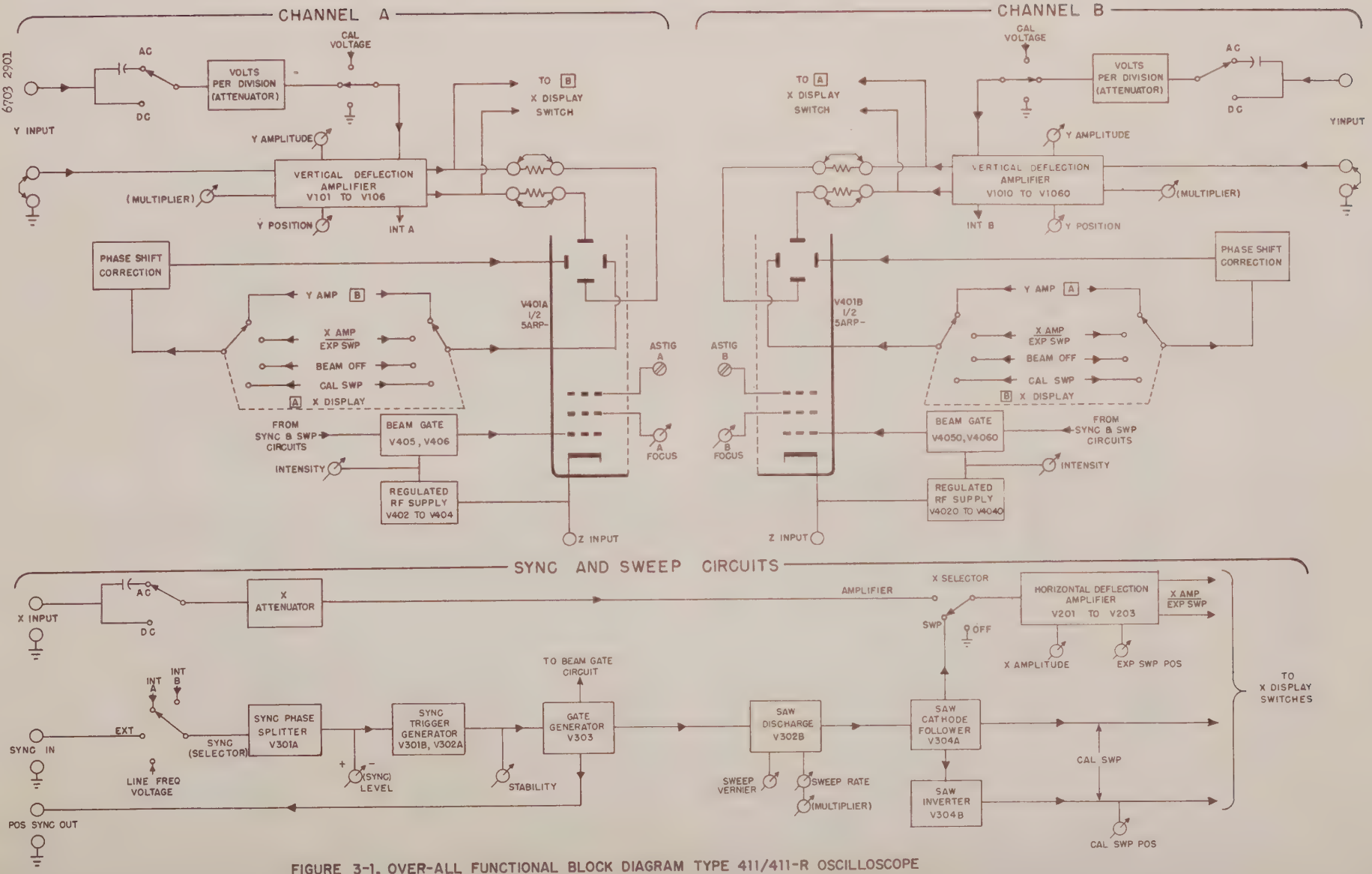


FIGURE 3-1. OVER-ALL FUNCTIONAL BLOCK DIAGRAM TYPE 411/411-R OSCILLOSCOPE

SECTION 3

THEORY OF OPERATION

3-1. GENERAL (Figure 3-1)

Certain subassemblies employed for Channel A are duplicated for Channel B. These are: (1) the Vertical Deflection Amplifier, (2) the Regulated RF Supply, and (3) the Beam Gate Circuit. Since these assemblies are identical for either channel, those components that have been added to form Channel B do not have new reference symbols. Instead, a zero suffix is added to the Channel B component to indicate that this item is part of Channel B, but is identical in performance to its mate in Channel A. For example, Channel B designation for V101 would be V1010 etc. Therefore, in the circuit description which follows, any reference to Channel A is equally applicable for Channel B.

To simplify circuit analysis, the instrument can be divided into five basic sections as follows: (1) Vertical Deflection Amplifier; (2) Horizontal Deflection Amplifier; (3) Sync and Sweep Circuits; (4) CRT, Beam Gate, and RF Supply; and (5) Heater and Low-voltage Supply. It is recommended that the schematics in Section 5 of this manual be referred to in following the circuit description. For information on service adjustments, refer to Maintenance, Table 4-2.

3-2. VERTICAL DEFLECTION AMPLIFIER

a. VOLTS PER DIVISION SWITCH

(1) 0.001 POSITION

Full sensitivity of the vertical deflection amplifier is realized in the 0.001 position in which there is no input attenuation or amplifier gain reduction.

(2) 0.01 POSITION

When the VOLTS PER DIVISION switch is set to 0.01, R119 is shunted across the plate load of the input cascode amplifier. Hence, the input signal is applied directly to the amplifier without attenuation, but the shunt resistor, R119, reduces the gain of the amplifier by a factor of 10.

(3) 0.1, 1, AND 10 POSITIONS

Three RC compensated attenuators precede the input cascode amplifier only in the 0.1, 1, and 10 positions of the VOLTS PER DIVISION switch. In other words, signals applied to Y INPUT are reduced in amplitude by a factor of 10 for each successive switching, before they are coupled to the input cascode amplifier.

b. MULTIPLIER SWITCH

(1) BAL POSITION

To facilitate adjustment of the Y MULT BAL control, the plates of V102A and V102B are tied directly together in the BAL position of the (MULTIPLIER) switch. The current in both halves of the cascode circuit is then adjusted by the Y MULT BAL control such that the plate-to-plate voltage across V102 equals zero. In this way, impedance changes across these plates, caused by switching the (MULTIPLIER) resistors, are not manifested as undesired voltage changes.

For those applications where an optimum common mode rejection is desired, an auxiliary balance entitled DYNAMIC BAL is provided. It is used in conjunction with the Y MULT BAL control to obtain common mode rejection up to 1000:1. See Section 4, Maintenance, for further information.

(2) X.1 POSITION

When the (MULTIPLIER) is set to X.1, the normal plate loads of the amplifiers are used; therefore, the amplifier operates at its maximum sensitivity.

(3) X.5 POSITION

When the (MULTIPLIER) is switched from X.1 to X.5, R130 is connected across R136 and R137 which reduces the gain of the amplifier by a factor of 5. Since the positioning circuit is also located at this point, it is evident that a 5:1 impedance change would also result in a 5:1 positioning-voltage change. In other words, any error voltage introduced by the Y POSITION control will be subject to a 5:1 change with a corresponding shift of the trace

on the screen. This slight dc shifting only occurs when switching between the X.1 and X.5 positions of the (MULTIPLIER).

(4) X1, X2, and X5 POSITIONS

Two sets of (MULTIPLIER) resistors are used for these positions. One set of resistors are switched in only when the VOLTS PER DIVISION switch is set to 0.001 AC/DC. They are R124, R125, and R126 which corresponds to the X1, X2, and X5 position of the (MULTIPLIER) respectively. The second set of resistors are switched in for all other positions of the VOLTS PER DIVISION switch. They are R121, R122, and R123 which corresponds to the X1, X2, and X5 position of the (MULTIPLIER), respectively. These shunt resistors are switched across the plate circuit load of the input cascode amplifier to vary its gain per knob markings. Thus, the sensitivity of the amplifier is determined by the product of the VOLTS PER DIVISION and (MULTIPLIER) control settings.

(5) CAL POSITION

When the (MULTIPLIER) switch is set to CAL, Y INPUT is disconnected and a ~~0.5~~ 0.25 volt peak-to-peak square-wave signal at power-line frequency is applied to the input cascode amplifier. Regardless of the setting of the VOLTS PER DIVISION switch, the sensitivity of the amplifier in the CAL position is 50 millivolts per ~~division~~ CM. The over-all sensitivity of the vertical deflection amplifier is set precisely to 50 millivolts per division by the Y CAL ADJ control, which sets the sensitivity of the amplifier to match the voltage of the internal calibrator.

c. DEFLECTION AMPLIFIERS

V101 and V102 are connected in a cascode type circuit to obtain the equivalent performance of pentodes. The advantages of this arrangement using the Type ECC91/6J6 are:

1) Minimum differences in change of transconductance of both halves of the tube due to heater-potential variations (ECC91/6J6 has a common cathode with a single heater).

2) High input impedance.

3) Low gas currents.

4) Two extra grids are available to facilitate dc balancing of the input stages.

The normally grounded grid of V101A is brought out to a front-panel binding post in order that balanced input operation may be obtained. For use of this feature, see Section 2, Operation. R109 and R111 in series with the grids of V101 protect the input circuit from damage due to excessive input voltages. Shunting capacitors C109 and C112 provide frequency compensation.

Undesirable negative voltages may be developed at the input grids due to gas currents. The grid load resistors are returned to a positive potential, which is controlled by the GRID CURRENT ADJ to cancel this negative potential.

V103 through V106 are connected as cathode-coupled dc amplifiers to provide push-pull signals for application to the vertical deflection plates.

3-3. HORIZONTAL DEFLECTION AMPLIFIER

a. X SELECTOR

The X SELECTOR switch provides for the selection of internal or external single-ended signals for horizontal deflection. The internal signal is obtained from the linear sweep circuit discussed elsewhere in this section. When X SELECTOR is set to AMPLIFIER, the internal sweep is disconnected and the X INPUT terminals are connected to the input cathode follower, V201. Attenuation of external ac or dc signals by factors of 1 or 10 may be obtained. The OFF position of this switch removes the input signal from the attenuator and grounds the grid of V201.

b. DEFLECTION AMPLIFIERS

V202 and V203 are connected as cathode-coupled dc amplifiers to provide push-pull signals for application to the horizontal deflection plates. The over-all gain of the X amplifier is controlled by the X AMPLITUDE control. The range of this control is such that it provides continuous expansion of the X INPUT or of the EXP SWP signal up to five times full scale. The positioning system provided is such that with a horizontal deflection equiv-

alent to five times full scale, any portion of this deflection may be centered on the screen by the EXP SWP POS control.

3-4. SYNC AND SWEEP CIRCUITS (See schematic for waveforms)

a. SYNC CIRCUIT

The SYNC (SELECTOR) switch provides selection of the synchronizing signal: INT signal obtained from a tap on the plate lead of V106 in the vertical channel), LINE frequency, or EXTernal (signal obtained from an external source). V301A functions as a sync phase splitter. The (SYNC) LEVEL control enables the operator to select the desired amplitude and polarity of the sync voltage. Following this control is the sync trigger generator, V301A and V302A. The bias level of this stage is established by the +120V·ADJ and TRIGGER service adjustments.

The sync trigger generator operates as follows: under stable conditions, V301B is fully conducting and V302A is at cutoff. V301B is initiated by waveform [B] applied to its grid, resulting in a sudden transition of V301B from full conduction to cutoff yielding waveform [C]. Conversely, V302A is suddenly fully conductive, resulting in a fast negative step, waveform [D], at its plate. Waveform [D] is coupled to the cathode of the gate generator, V303, through a series-triggering crystal diode, CR301. This diode serves as a sync lockout stage during the forward sweep time as follows: when V303 is triggered, its cathode voltage drops approximately eight volts. Since the plate of CR301 is connected to this point, it becomes automatically nonconductive during the forward sweep time, thereby preventing the passage of unwanted sync signals.

b. SWEEP CIRCUIT

(1) GATE GENERATOR

Depending on the setting of the STABILITY control, V303 operates as a bistable or a free-running multivibrator. In the bistable condition, the STABILITY control is set such that, initially, V303A is at cutoff and V303B is fully conducting. Waveforms [E], [F], and [G] are developed when V303 is initiated. Waveform [G] is coupled to the POS SYNC OUT terminal and is coincident with the start of the sweep to enable synchronization of auxiliary equipment. This waveform is also used to initiate the beam gate generator, V405, which provides a brightening voltage during forward sweep time.

(2) POSITIVE SAW GENERATION

The negative gate output, waveform E, is coupled to the saw discharge tube, V302B, which is normally conducting and maintaining the sweep rate capacitor in a discharged state. Waveform E turns off V302B and allows the voltage at its plate to rise at a rate determined by the product of R and C as selected by the SWEEP RATE and (MULTIPLIER) controls. The resultant sawtooth voltage is coupled to the saw cathode follower, V304A.

The voltage at the cathode of V304A is fed back to the grid of the nonconducting gate tube, V303B via the SWEEP DURATION service adjustment. This restores the gate generator to its initial operating condition (when the sawtooth voltage reaches a predetermined level) thus terminating the sweep. For driven sweep operation, the beam will sweep across the screen again only upon the application of another negative signal from the sync trigger generator to V303.

A high degree of linearity is achieved by causing the dc voltage of the charging source to rise at saw rate through use of a gas tube, V305, coupled to the sweep charging resistors. This essentially provides a constant-current charging source for the sweep capacitor. Since the charge across any capacitor is directly proportional to the current flowing into it, a constant (unvarying) current results in a uniform increase in charge or a linear sawtooth waveform.

(3) CALIBRATED SWEEP

The calibrated sweep writing rate in milliseconds or microseconds per centimeter is equal to the product of the SWEEP RATE and (MULTIPLIER) controls only when the X DISPLAY switch is set to CAL SWEEP.

Waveform H from the saw cathode follower, V304A, is directly coupled to horizontal deflection plate D2 through a saw level stage, V305. Simultaneously, output of the same polarity and of reduced amplitude is applied to the grid of the saw inverter, V304B. Waveform I at the plate of V304B is opposite phase but of the same amplitude as waveform H, is coupled to the other horizontal deflection plate, D1.

Positioning of the high-level calibrated sweep is accomplished by coupling waveform I through two neon bulbs, E301 and E302. These bulbs provide two basic dc levels of negative saw without attenuation. The highest level is established at the plate of V304B and the second level is about 120 volts below this point. The CAL SWP POS is shunted across these bulbs with the control arm connected to deflection plate D1. Capacitor C342 serves to prevent variation in high-frequency response with changes in the setting of the CAL SWP POS control.

(4) EXPANDED SWEEP

When the X DISPLAY switch is set to CAL SWP the high-level sweep is connected directly to the horizontal deflection plates. In the X AMP/EXP SWP position, the high-level saw is disconnected from the horizontal plates and a portion of the positive saw is coupled to the input of the horizontal cathode follower, V201. The sweep is then converted to push-pull output and may be expanded up to five times full scale by the horizontal deflection amplifiers V202 and V203, before application to the deflection plates.

3-5 CRT, BEAM GATE, AND RF SUPPLY

a. CATHODE-RAY TUBE

A Type 5ARP- dual-gun cathode-ray tube is used, operating at a total accelerating potential of 2500 volts. Excellent spot size, focus, and pattern brilliance are features of this mono-accelerator tube.

The Deflection Plate CORRection adjustments, R433 and R4330, are provided to establish the relative horizontal position of the two beam traces when Channel A and Channel B X DISPLAY switches are both set to CAL SWP. Additional information is given in Section 4, Maintenance.

b. FOCUS

The setting of the FOCUS control establishes the relative potential difference between the focus anode and cathode of V401. The vertical deflection plates, D3 and D4, and the horizontal deflection plates, D1 and D2, and operate at an average dc potential of about 250 volts above ground. To avoid beam distortion, the

ASTIGmatism and PRE-ACCELerator adjustment must be set such that the voltage across their respective arms to ground is very nearly equal to the average deflection plate voltage. See Maintenance, Section 4, for additional information.

c. INTENSITY MODULATION

For intensity modulation of the beam, positive (blanking) or negative (brightening) signals may be applied to the Z INPUT terminal through coupling capacitors, to the cathode of V401.

d. BEAM GATE AND INTENSITY CIRCUITS

(1) GENERAL DESCRIPTION

The primary functions of the beam gate, V405, are: (1) to provide return trace blanking for recurrent sweep operation, and (2) when driven sweep operation is desired, to automatically turn on the cathode-ray tube beam for the duration of the forward sweep interval and then turn it off automatically at the end of this interval. This latter feature prevents film fogging and/or screen burning prior to the initiation of driven sweep.

A basic function of the beam gate generator is to transfer the brightening gate from a low dc level (about 300 volts) to the high dc level of the cathode-ray tube grid (negative high voltage).

These functions are resolved by using a conventional bistable multivibrator, V405. The mean dc level of this stage is equal to the average level of the cathode-ray tube accelerating potential. Thus, only short pulses are needed to trigger V405 on or off, enabling the use of a much smaller coupling capacitor.

(2) DETAILED DESCRIPTION

Under stable conditions, the constants of the beam gate circuit are such that V405A is at cutoff, and V405B is fully conducting. When the sweep starts, the positive leading edge of the gate coupled from the plate of V303B is applied to the grid (pin 2) of V405A, turning on this stage and turning off V405B. Thus, the grid of the cathode-ray tube is held above cutoff for the duration of the forward

sweep time. V405 is restored to its original condition by the negative trailing edge of the gate.

Plate voltages for the beam gate circuit are derived from a separate power supply which is completely isolated from ground and is tied into the -HV supply via the INTENSITY control.

(3) INTENSITY

Adjustment of the INTENSITY control varies the grid bias of the cathode-ray tube by changing the entire dc level of the isolated supply with respect to the -HV supply. When the INTENSITY control is turned fully counterclockwise, and V405A is fully conducting, the grid of V401 is 100 volts more negative than its cathode, thus extinguishing the cathode-ray tube beam.

e. REGULATED RF SUPPLY

(1) GENERAL DESCRIPTION

Operating potentials for the proper intensity and focusing of the cathode-ray tube beam are derived from the regulated rf supply. Regulation is accomplished by sampling a portion of the rectified output, and feeding a correcting signal back through V403 to the screen grid of V404.

(2) DETAILED DESCRIPTION

The rf power oscillator, V404, operating in the vicinity of 150-200 Kc, develops an ac potential across the primary of T401. The amplitude of this voltage is proportional to the screen voltage applied to V404. Hence a change in the rectified output can be corrected by an appropriate (increase or decrease) change in V404 screen potential. For example, a decrease in the rectified output would result in an error voltage fed back to a two stage direct-coupled control amplifier, V403A and V403B. These stages supply the correction signal which is coupled to the screen of V404. The screen voltage is increased, which increases the ac output voltage across T401, thus, compensating for the decrease in output voltage mentioned earlier.

The advantages of an rf supply system of generating CRT accelerating potentials, compared to that of a conventional "brute force," low-frequency systems are: (1) Relative ease of incorporating control amplifiers to maintain constant, effectively low output impedance; (2) elimination of high-voltage, high-capacitance filters which are expensive and bulky; and (3) sharp reduction in shock hazard due to the smaller capacitors used in the filter system.

3-6. HEATERS AND LOW-VOLTAGE SUPPLY

V504 is connected in a conventional full-wave rectifier circuit. The rectified output is capacitively filtered by C505 and C506. These capacitors are shunted by resistors R512 and R513 to equalize the voltage across them.

Regulated output, obtained from conventional voltage regulator circuitry, of +400, +185, +150, +120, and -85 volts are available. DC regulated heater voltage is provided for the vertical input cascode and interstage amplifiers, V101 - V104. This voltage is derived from a full-wave bridge rectifier, CR503, the output of which is coupled to a transistorized heater-voltage regulator.

SECTION 4

MAINTENANCE

WARNING

OBSERVE THE FOLLOWING PRECAUTIONS

WHEN NECESSARY TO ENERGIZE THE

EQUIPMENT WITH THE CABINET REMOVED:

1) Never work alone.
2) Make sure the chassis is properly grounded.
3) Remove power cord before changing any tubes.
4) Before touching any components, short the terminals to remove any possible charge that may remain after turning off the power.

4-1. GAINING ACCESS TO THE CHASSIS

The unit is enclosed in a cabinet which is composed of four removable panels (top, bottom, left, and right sides). To gain access to the chassis, remove the two screws securing the top edge of each side panel and loosen the bottom edge screws. After the side panels are removed, the top and bottom panels may be taken off if desired. To take off the bottom panel, remove the two flat head screws located on the fold-over on each side. The top panel is similarly removed. Note: the top panel will not normally require removal.

4-2. SERVICE ADJUSTMENTS

Do not touch any service adjustments unless tests clearly indicate the need to do so. Such adjustments should not be attempted without a complete understanding of the proper procedure. Consult Tables 4-1 and 4-2 for special instructions. The procedures given in Table 4-2 are based on the assumption that no tubes or components are faulty. Whenever these conditions are not met, see paragraph 4-3, Servicing Hints.

4-3. SERVICING HINTS

In the event of improper equipment performance, the following suggestions are recommended:

1) Note that all tube heaters are lit or feel tubes for warmth.

2) Check all supply voltages; includes the ac power line, +400V, +185V, +150V, +120V, and the -85V supplies.

3) Do not tamper with any of the service adjustments as this will only complicate servicing.

4) The first step in correcting any trouble or failure that may occur is to isolate the section of the circuit causing the trouble. A separate schematic for each basic section of the instrument is provided as follows:

   a. Vertical Deflection Amplifier
   b. Horizontal Deflection Amplifier
   c. Sync and Sweep Circuits
   d. CRT, Beam Gate, and RF Supply
   e. Heaters and Low-voltage Supply

5) Localizing the trouble is made easier by use of a test probe coupled to an oscilloscope. Key waveforms are shown on the Sync and Sweep schematic.

6) When a point is reached where normal performance ceases abruptly, a replacement tube should be tried before attempting any other tests. In some cases, a second new tube may be tried.

> CAUTION
>
> To avoid damage to the Zener diode in the heater regulator, do not operate this equipment unless all Y amplifier input tubes are properly plugged in.

7) Replacement of certain tubes may require resetting of one or more service adjustments. Consult Table 4-3. For optimum stability, the new tube should be allowed a warmup time of at least 10 minutes before making any final service adjustments.

8) As a further aid to servicing, see Table 4-4, Tube Failure and Adjustment Misalignment Chart. In many cases, valuable assistance in trouble shooting can be obtained by comparing the doubtful performance of a tube in one channel to that of its properly functioning mate in the other channel.

9) If after tube replacement the trouble persists, replace the original tube in its socket and check for proper voltage and resistance per Tables 4-5 and 4-6.

10) Maintain a high quality of workmanship. Use a clean bench and soldering iron; keep solder joints smooth and bright; do not overheat any component while soldering.

4-4. CATHODE-RAY TUBE REPLACEMENT

> CAUTION
>
> The cathode-ray tube should be handled with great care to prevent breakage and/or serious personal injury from flying glass. Do not employ force at any time. As an added precaution, it is advisable to wear safety goggles and gloves.

The following step-by-step procedure is suggested for replacing the cathode-ray tube:

1) Turn off the power.

2) Remove bezel, held by four screws at front panel.

3) Loosen the screws on either side of the rear magnetic shield and slide it back.

4) Remove the cathode-ray tube ring base and rear sockets.

5) Loosen the cathode-ray tube neck clamp. The screw which secures this clamp is available through the access hole in the right side of the magnetic shield.

6) Remove the tube through the front panel opening

7) Remove the cork-lined shield from the old tube and install it on the new tube.

8) Install new tube through front panel opening and replace the bezel.

9) Replace the tube sockets and the rear magnetic shield.

10) Apply power and check the sweep; if not horizontal, rotate the tube to coincide with the horizontal scale lines.

WARNING: HIGH VOLTAGE!

11) Tighten the cathode-ray tube clamp securely to prevent rotation in handling.

4-5. ILLUMINATED SCALE LAMP AND PILOT LAMP REPLACEMENT

a. Defective scale lamps are removed as follows:

1) Turn off power and remove the side panels.

2) Remove the appropriate lamp assembly located on the rear side of the front panel by depressing the spring clip. The defective bulb may then be removed and replaced.

b. Defective pilot lamp is removed as follows:

1) Turn off power and remove bottom panel.

2) With the unit upside down, replace the defective bulb.

TABLE 4-1

TEST EQUIPMENT REQUIRED FOR SERVICE ADJUSTMENTS

REF. NO.	DESCRIPTION	RANGE OR CHARACTERISTICS
(1)	Volt-ohmmeter	20K ohms/volt Test Meter or Vacuum Tube Voltmeter
(2)	Square-wave Generator	1 Kc to 100 Kc; 75 volts output
(3)	Voltage Calibrator	0.1 volt to 100 volts; ±1%
(4)	Sine-wave Generator	1 Kc to 100 Kc; ±1%
(5)	Time calibrator	Pulse repetition rate 1 Kc and 10 Kc; ±1%; 2 volts peak

TABLE 4-2

SERVICE ADJUSTMENT CHART

PRECAUTION

DO NOT SET ANY SERVICE ADJUSTMENT WITHOUT FOLLOWING SPECIFIC INSTRUCTIONS AND SEQUENCE GIVEN IN TABLE 4-2. SOME ADJUSTMENTS ARE INTERDEPENDENT.

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
POWER SUPPLIES AND CRT		
+400V ADJ (R505) Fig. 4-6	(1)	Connect a voltmeter between pin 3 or 6 of V502 and ground. Adjust R505 for 400 volts
-HV ADJ (R405 & R4050) Fig. 4-8	(1)	1. Connect a voltmeter between arm of Channel A INTENSITY control and arm of PRE-ACCEL control 2. Adjust R405 for -2500 volts 3. Repeat steps 1 and 2 using Channel B INTENSITY control and R4050
ASTIG (R401 & R4010) and PRE-ACCEL (R410) Fig. 4-8	(1)	The optimum setting for these three adjustments will occur when the voltage across their respective arms to ground is very nearly equal to the average deflection plate voltage 1. Set Channel A (MULTIPLIER) to CAL and adjust Y AMPLITUDE for full scale deflection. Adjust sweep controls to obtain four cycles of the calibration pattern

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
POWER SUPPLIES AND CRT (Contin.)		
		2. Connect a VTVM between the arm of the PRE-ACCEL (R410) and ground. Adjust R410 for 250 volts; remove the meter 3. Adjust R401 while rocking Channel A FOCUS control back and forth across the optimum focus setting. A point should be found in R401 setting which gives the best focus throughout the trace length 4. Repeat steps 1 and 3 using Channel B controls and R4010 5. With a VTVM, measure the X and Y deflection plate voltages of both channels with respect to ground and then compute the average potential. Measurements are easily made at the deflection plate terminals located at rear of unit 6. Measure the voltage across the arms of R401 and R4010 and ground with a VTVM. These voltages should be within $\pm$20 volts of the average deflection plate voltage computed in step 5 7. If the voltages across R401 and R4010 exceeds the average deflection plate potential by more than 20 volts, turn R410 slightly clockwise; if lower by the same amount, turn R410 counterclockwise

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
POWER SUPPLIES AND CRT (Contin.)		
		8. Repeat steps 3 through 6 until all voltages are equal to within about 20 volts. NOTE: In some cases, better tracking and lower distortion may be possible by deviating slightly from the above procedure; that is, by operating the PRE-ACCEL adjustment at a different voltage level than that of the astigmatism adjustment. Therefore the final setting of these controls is dictated more by the performance of the cathode-ray tube than by the resultant voltages.
CHANNEL A OR CHANNEL B VERTICAL DEFLECTION AMPLIFIER		
Y LIN (R145 & R1450) Figs. 4-1 & 4-4	--	R145 is used to select the proper operating point for V105 and V106 so that optimum vertical linearity may be obtained 1. Apply a signal to Y INPUT and adjust for three divisions of vertical deflection 2. Position the pattern to the upper and lower limits of the screen and note any change in pattern size 3. The pattern size should not vary by more than $\pm$2% (0.2 division). If this figure is exceeded, adjust R145 until a minimum change in size occurs

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
CHANNEL A OR CHANNEL B VERTICAL DEFLECTION AMPLIFIER (Contin.)		
		4. If satisfactory adjustment cannot be achieved, replace V105 and/or V106 5. After Y LIN is properly adjusted, recheck the ASTIG adjustments 6. Repeat the above steps for Channel B
VOLTS PER DIVISION Compensation capacitors Figs. 4-2 & 4-5	(2)	Apply a 10 Kc square wave signal to Y INPUT and adjust the capacitors listed to obtain flat-top square wave VOLTS PER DIVISION set to — Adjust Chan. A — Chan.B .1 — C102 — C1020 1 — C104 — C1040 10 — C106 — C1060
GRID CURRENT ADJ (R107 & R1070) Figs 4-1 & 4-4	--	R107 is used to cancel the negative voltage developed at the grids of V101 due to gases and leakage currents 1. Ground the normally ungrounded terminal of Y INPUT 2. Set (MULTIPLIER) to X.1 and VOLTS PER DIVISION to .01 AC ; obtain a trace on the screen

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
CHANNEL A OR CHANNEL B VERTICAL DEFLECTION AMPLIFIER (Contin.)		
		3. Adjust R107 until no depositioning of the trace occurs when the VOLTS PER DIVISION control is switched from .01 to .1 AC. Inability to properly make this adjustment indicates excessive gas and leakage current in V101, which should be replaced
Y MULT BAL (R115 & R1150) Front panel	--	4. Set (MULTIPLIER) to BAL and center the trace with Y POSITION 5. Set (MULTIPLIER) to X.1 and recenter the trace with Y MULT BAL 6. If necessary repeat steps 4 and 5 until no vertical shifting of the trace is noted while switching through the ranges of the VOLTS PER DIVISION and (MULTIPLIER) controls. Note that when the (MULTIPLIER) is switched between the X.1 and X.5 position, a dc shifts occurs which cannot be balanced out. An explanation of why dc shifting occurs only on this range and cannot be balanced out is described in Section 3, Theory of Operation.
Y AMPLITUDE DC BAL (R133 & R1330) Figs. 4-2 & 4-5	--	7. Set MULTIPLIER to BAL

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
CHANNEL A OR CHANNEL B VERTICAL DEFLECTION AMPLIFIER (Contin.)		
		8. Rotate Y AMPLITUDE fully clockwise and center the trace with Y POSITION 9. Set Y AMPLITUDE fully counter-clockwise and recenter the trace with Y AMPLITUDE DC BAL 10. If necessary, repeat steps 8 and 9 until no displacement of the trace is noted while varying Y AMPLITUDE. Inability to properly make this adjustment indicates tube selection for V103 and V104 positions may be necessary 11. Repeat the above steps for Channel B
DYNAMIC BAL (R128 & R1280) Figs. 4-1 & 4-4	(4)	R128 is used to adjust the vertical deflection amplifier for optimum common mode rejection 1. Remove the shorting link, connect Channel A Y INPUT terminals together, and set front-panel controls for maximum input sensitivity 2. Apply a 1 Kc sine wave signal of about 0.2 volt rms to Y INPUT; note the resultant deflection amplitude

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
CHANNEL A OR CHANNEL B VERTICAL DEFLECTION AMPLIFIER (Contin.)		
		3. Turn R128 clockwise ** about 10° and bring the trace back on the screen with the Y MULT BAL control. A reduction in deflection amplitude should be noted 4. Continue turning R128 clockwise while correcting with the Y MULT BAL control until minimum possible deflection is reached 5. Repeat the above steps for Channel B **NOTE: If clockwise rotation of R128 causes an increase rather than a decrease in deflection, turn R128 counterclockwise in steps 3 and 4

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
CHANNEL A OR CHANNEL B VERTICAL DEFLECTION AMPLIFIER (Contin.)		
CAL VOLTS (R524 & R5240) Fig. 4-3		R524 is used to set the output of the voltage calibrator to ~~0.5~~ 0.25 volt 1. Set VOLTS PER ~~DIVISION~~ CM. to .01 DC and (MULTIPLIER) to ~~X.1~~ X1 2. Apply a ~~0.10~~ 0.25 volt signal from an external voltage calibrator to Y INPUT 3. Advance Y AMPLITUDE control for exactly ~~full~~ HALF scale deflection (5 CM.) NOTE: Changes in the average horizontal deflection plate voltage (D1 - D2) will cause minor changes in Y deflection sensitivity (D3 - D4). These changes occur as a function of cal sweep positioning. To minimize this effect, all operations requiring precision from the Y amplifier should be performed with the calibrated sweep starting at the left edge of the illuminated scale.
*Number shown ( ) corresponds to reference number of test equipment in Table 4-1		4. SET MULTIPLIER TO CAL. 5. ADJUST R524 (R5240) FOR THE SAME HALF-SCALE DEFLECTION (5 CM.)

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
SYNC AND SWEEP CIRCUITS		
+120V ADJ (MODE RANGE R515) Fig. 4-6		R515 is adjusted so that the STABILITY control range is centered 1. This range is established by: (1) the point where synchronized driven sweep cuts off; and (2) at the threshold of recurrent sweep with no sync. Variation of this setting, caused by drift and component aging, should be limited so that recurrent sweep is obtained when the STABILITY control is turned not less than 15° away from its fully clockwise position.
TRIGGER (R307) Fig. 4-5	(5)	R307 is used to control the threshold bias of V301 1. Set up the instrument for driven sweep and the SWEEP RATE controls for 1 microsecond/centimeter 2. Apply pulses with a period of 1000 microseconds from a Time Calibrator to Channel A or B Y INPUT 3. Using the TRIGGER adjustment (R301) adjust pulse waveform for maximum leading edge and with good stability 4. As a further check of the TRIGGER setting, set up the instrument for 2 or 3 cycles of the internal calibrator signal at an amplitude of about 5 centimeters 5. Starting from full rotation (either + or -), slowly turn the (SYNC) LEVEL control towards zero (center). The sweep should start higher up on the rising portion of the waveform until the sweep starting point is coincident with the flat-top portion of the waveform. Any additional rotation of the

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
SYNC AND SWEEP CIRCUITS (Contin.)		
		(SYNC) LEVEL control beyond this point should cause the sweep to stop abruptly and with no indication of random triggering 6. In practice, the (SYNC) LEVEL control is turned to either extreme. However it is desired to initiate the sweep from some definite point on the waveform, this control may be adjusted to give this effect
SWEEP DURATION (R323) Fig. 4-5	--	R323 is used to control sweep length 1. Set up sweep controls for calibrated sweep and obtain 6 stable cycles of the internal calibrator signal on the screen 2. Adjust R323 for a sweep length of 10.5 centimeters (minimum)
SWEEP CALIBRATE (R344) and Trimmers (C312 & C313) Figs. 4-5 & 4-4	(4)	R344 is used for adjusting the overall sweep writing rates. C312 and C313 are used for adjusting the upper and lower range of the (MULTIPLIER) control 1. Allow a minimum warm-up time of 15 minutes 2. Recheck the -HV ADJ and ASTIG adjustments for both channels 3. Set the adjustments listed in the table below until 10 cycles of the applied signal appears precisely in 10 centimeters

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
SYNC AND SWEEP CIRCUITS (Contin.)		
		NOTE: Adjustments must be made in the sequence given SWEEP RATE set to / (MULTIPLIER) set to / Frequency required / Adjust 1 MS/CM / X1 / 1 Kc / R344 1 uS/CM / X10 / 100 Kc / C312 10 uS/CM / X1 / 100 Kc / C313
HORIZONTAL DEFLECTION AMPLIFIER		
X BAL (R211) Fig. 4-5	--	R211 is used to set the cathode-to-cathode voltage of V201 so that both ends of the X AMPLITUDE control are at the same dc potential 1. Set X SELECTOR to OFF and X DISPLAY to X AMP/EXP SWP 2. Rotate X AMPLITUDE fully counterclockwise 3. Center the spot with EXP SWP POS 4. Rotate X AMPLITUDE fully clockwise and recenter the spot with X BAL 5. If necessary, repeat steps 2 through 4 until no change in horizontal positioning of the spot is observed while varying X AMPLITUDE control throughout its range. Inability to achieve proper balance indicates need for replacing V201 or V202

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
HORIZONTAL DEFLECTION AMPLIFIER (Contin.)		
SAW DC LEVEL (R206) Fig. 4-5	--	R206 is used to establish the average dc level of the saw at zero potential 1. Set (MULTIPLIER) to CAL, X SELECTOR to SWP, and X DISPLAY to X AMP/EXP SWP 2. Adjust appropriate controls to obtain a stable pattern of about 6 cycles 3. Adjust R206 until pattern expands equally about center of trace as X AMPLITUDE control is varied NOTE: Proper adjustment of R206 is dependent to some extent on the X LIN adjustment. Hence, it may be necessary to alternate between these two adjustments in order to obtain the proper results
X LIN (R218) Fig. 4-5	--	R218 is used to select the proper operating point for V203 so that optimum horizontal linearity may be obtained 1. Set X SELECTOR to SWP and obtain a full scale stable pattern of about 6 cycles of the calibrator waveform 2. Adjust R218 to satisfy the following conditions: a. The Y delfection sensitivity does not change more than 1% (±0.1 division) when X DISPLAY is switched from CAL SWP to X AMP/EXP SWP

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
HORIZONTAL DEFLECTION AMPLIFIER (Contin.)		
		b. No obvious distortion appears on any on-screen portion of the fully expanded sweep across the EXP SWP POS range
Linearity Trimmer (C204) Fig. 4-4	(4)	C204 is used to adjust the linearity of the expanded sweep at high frequencies 1. Set SWEEP RATE to 1 uS/CM, (MULTIPLIER) to X10, X SELECTOR to SWP, and X DISPLAY to X AMP/EXP SWP 2. Obtain a stable sine wave display with the frequency set such that a large number of cycles appear on the screen 3. Adjust C204 for optimum linearity at the left edge of this display
X SELECTOR Compensation Capacitor (C202) Fig. 4-4	(2)	Apply a 10 Kc square wave to X INPUT. Proper adjustment of C202 is obtained when the dots at each end of the horizontal trace are of maximum relative intensity and in sharpest focus
Phase Shift Correction (C420/C4200) Figs. 4-3 & 4-6	(4)	When the X DISPLAY switches are set for identical deflection amplifier operation, the deflection plates impose a capacitive load on the opposite channel amplifier. To minimize X and Y amplifier relative phase shift, C420/C4200 are used to insert the same capacitive load on the amplifiers for the other positions of the X DISPLAY switches

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
HORIZONTAL DEFLECTION AMPLIFIER		
		1. Set VOLTS PER DIVISION to .01 and (MULTIPLIER) to X5 (both channels) 2. Set Y AMPLITUDE fully clockwise until switch is actuated (both channels) 3. Set Channel A X DISPLAY to Y AMP B and Channel B X DISPLAY to Y AMP A 4. Apply a 100 Kc, 0.15 volt rms sinusoidal signal to Y INPUT of both channels 5. Turn off Channel B INTENSITY. A single diagonal trace having a slight phase shift should be noted. 6. Set Channel B X DISPLAY to X AMP/EXP SWP and adjust C4200 for the same degree of phase shift noted in step 5 7. Repeat steps 5 and 6 using Channel A INTENSITY and X DISPLAY controls and adjusting C420
HORIZONTAL DEFLECTION PLATE TRACKING		
DP CORR (R433 & R4330) Fig. 4-8	(1)	R433 and R4330 are adjusted to superimpose the two beams of the cathode-ray tube in the X direction

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
HORIZONTAL DEFLECTION PLATE TRACKING (Contin.)		
		1. Set X SELECTOR to SWP and both X DISPLAY switches to CAL SWP 2. Set (MULTIPLIER) of both channels to CAL and adjust sweep controls to obtain four cycles of the calibrator pattern 3. Adjust Y AMPLITUDE controls to obtain equal vertical deflections (about 5 divisions) 4. Set R405 ($-HV_A$ ADJ to -2500 volts (measured with respect to arm of PRE-ACCEL adjustment) 5. Set 4050 ($-HV_B$ ADJ) to give identical amplitudes of horizontal deflection on both channels 6. Starting from full clockwise, adjust DP CORRection (either R433 or R4330, but not both) to superimpose traces 7. Upon completion of steps 1 through 5, check to see that no portion of the trace is displaced from each other horizontally by more than 0.02 inch (0.5 mm) 8. Check tracking and focusing near edge of screen. If unsatisfactory, try a new setting for PRE-ACCEL adjustment

*Number shown ( ) corresponds to reference number of test equipment in Table 4-1

TABLE 4-2. SERVICE ADJUSTMENT CHART (Contin.)

NAME AND LOCATION	*TE	ADJUSTMENT PROCEDURE
HORIZONTAL DEFLECTION PLATE TRACKING (Contin.)		
		(described near beginning of this Table) and repeat steps 4 through 6. Continue this procedure until the best compromise between tracking and focusing is achieved Note: Due to the effect of the earth's magnetic field, the tracking adjustments will vary as function of the orientation of the instrument with respect to this field.

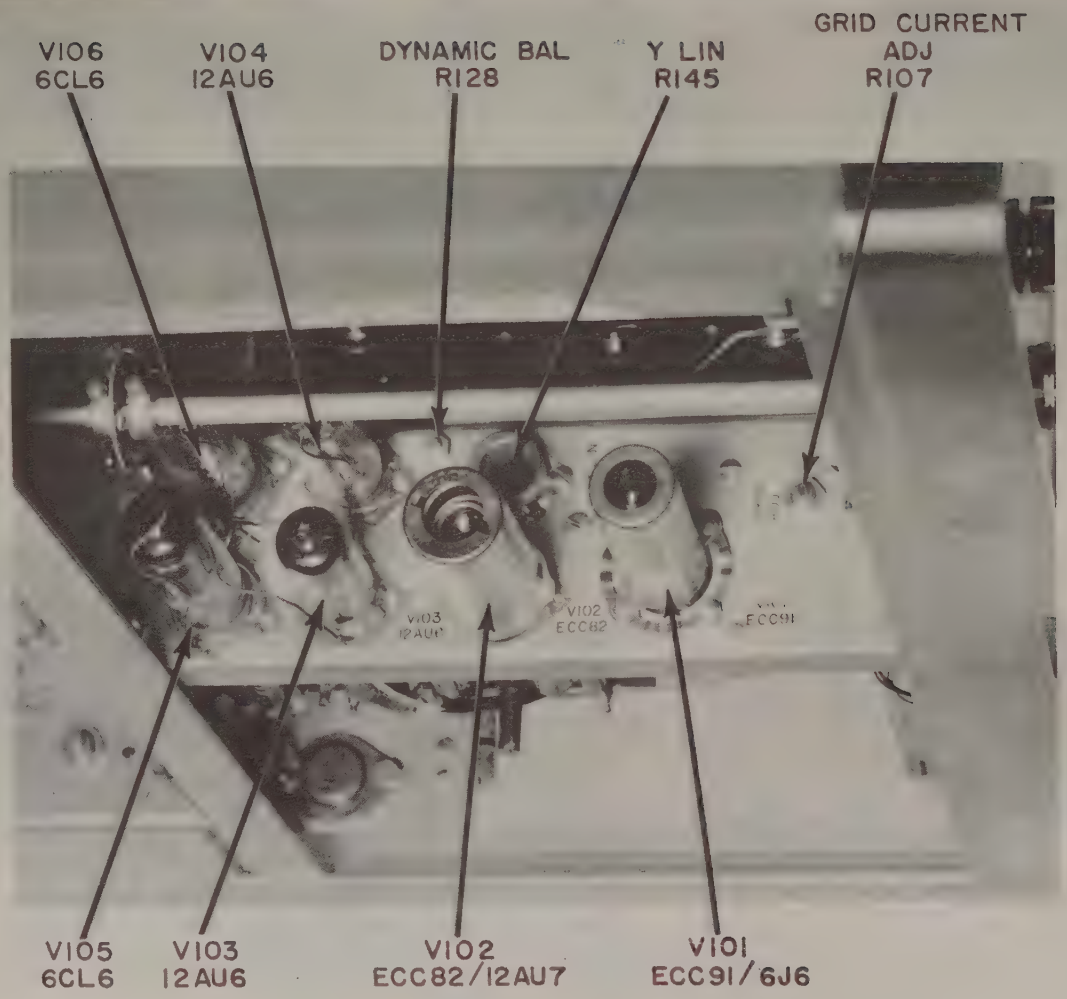


FIGURE 4-1. SERVICE ADJUSTMENTS AND TUBE LOCATIONS- TOP LEFT FRONT VIEW.

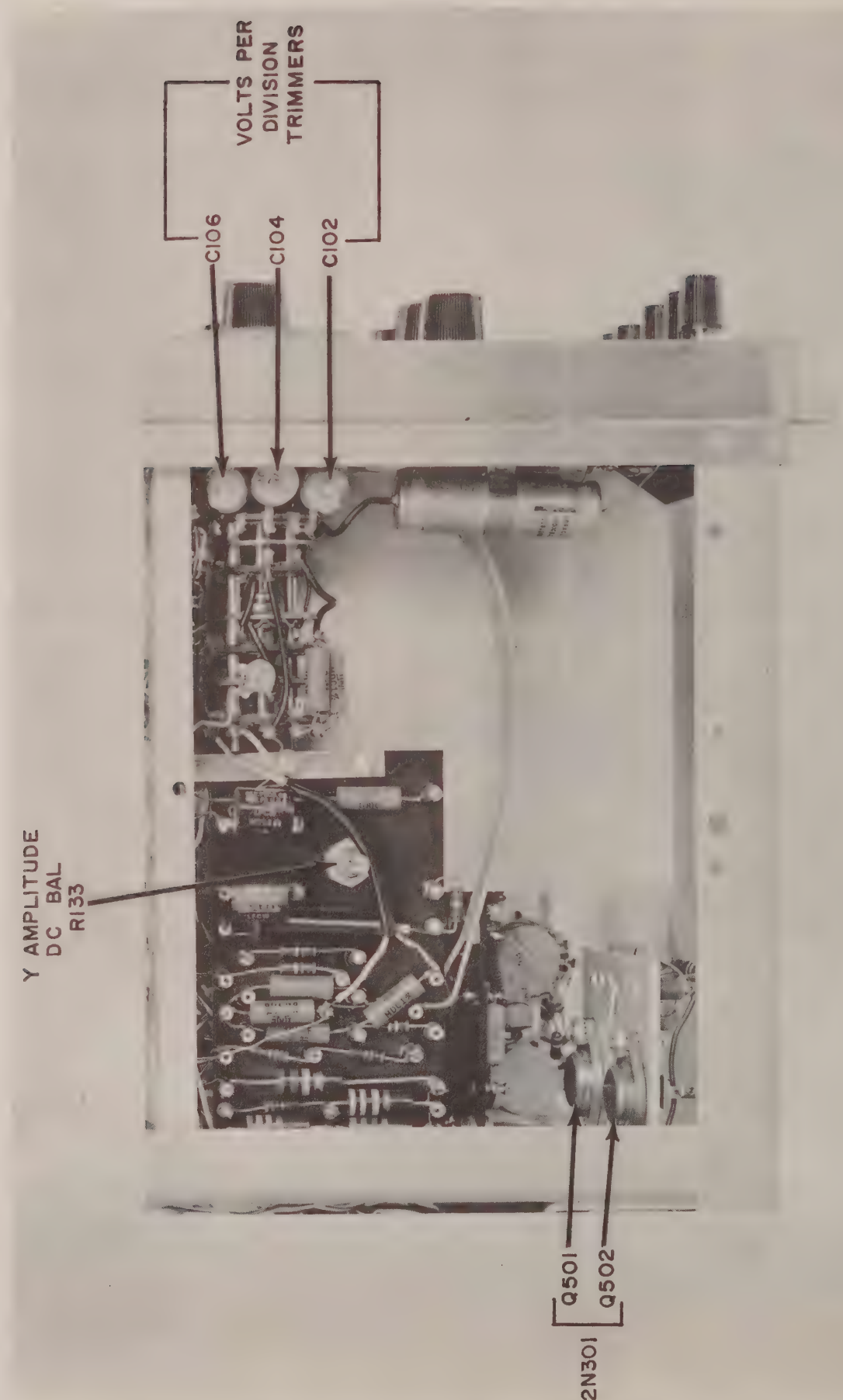


FIGURE 4-2. SERVICE ADJUSTMENTS AND TRANSISTOR LOCATIONS—LOWER LEFT FRONT VIEW.

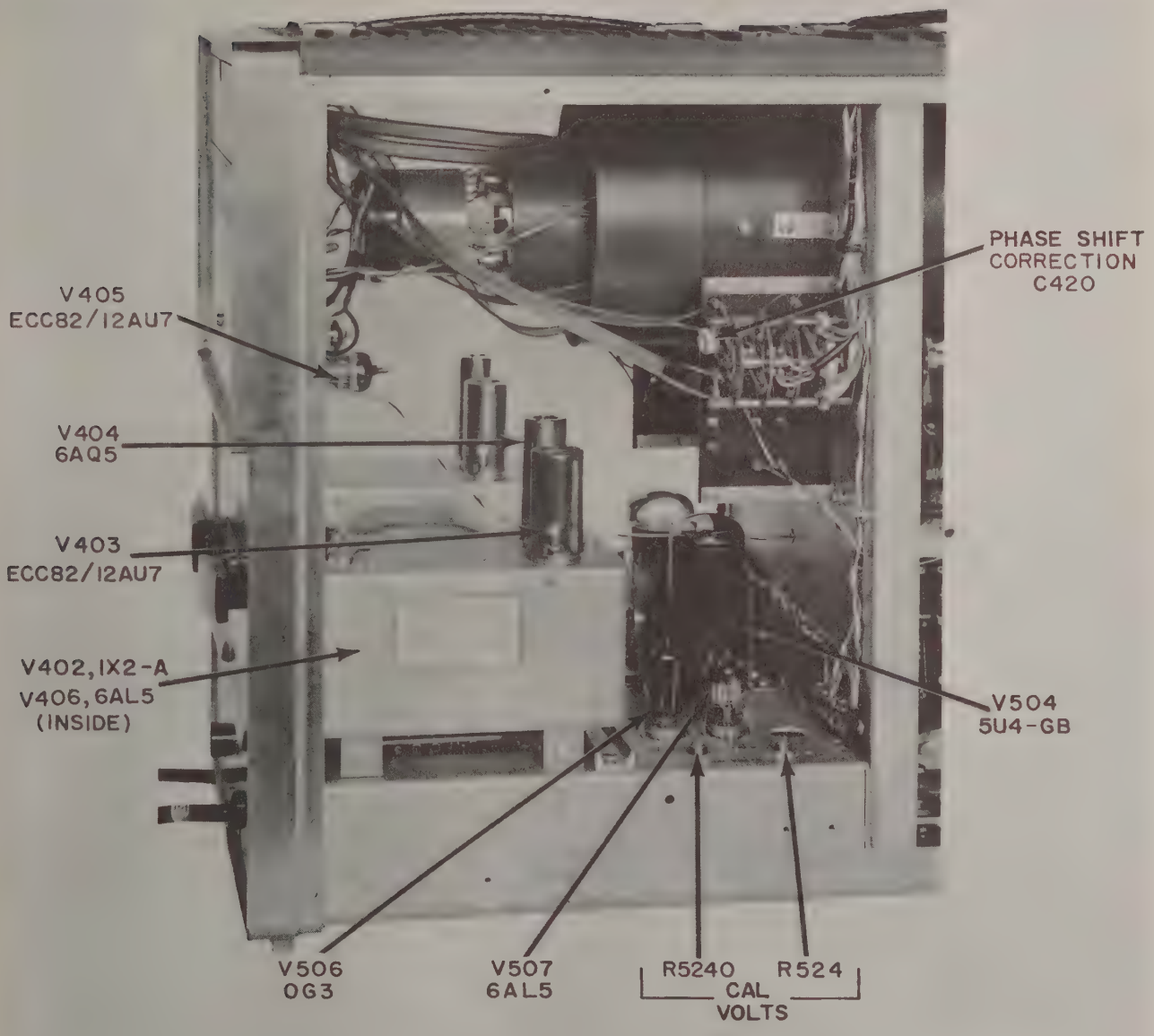


FIGURE 4-3. SERVICE ADJUSTMENTS AND TUBE LOCATION - LEFT REAR CHASSIS

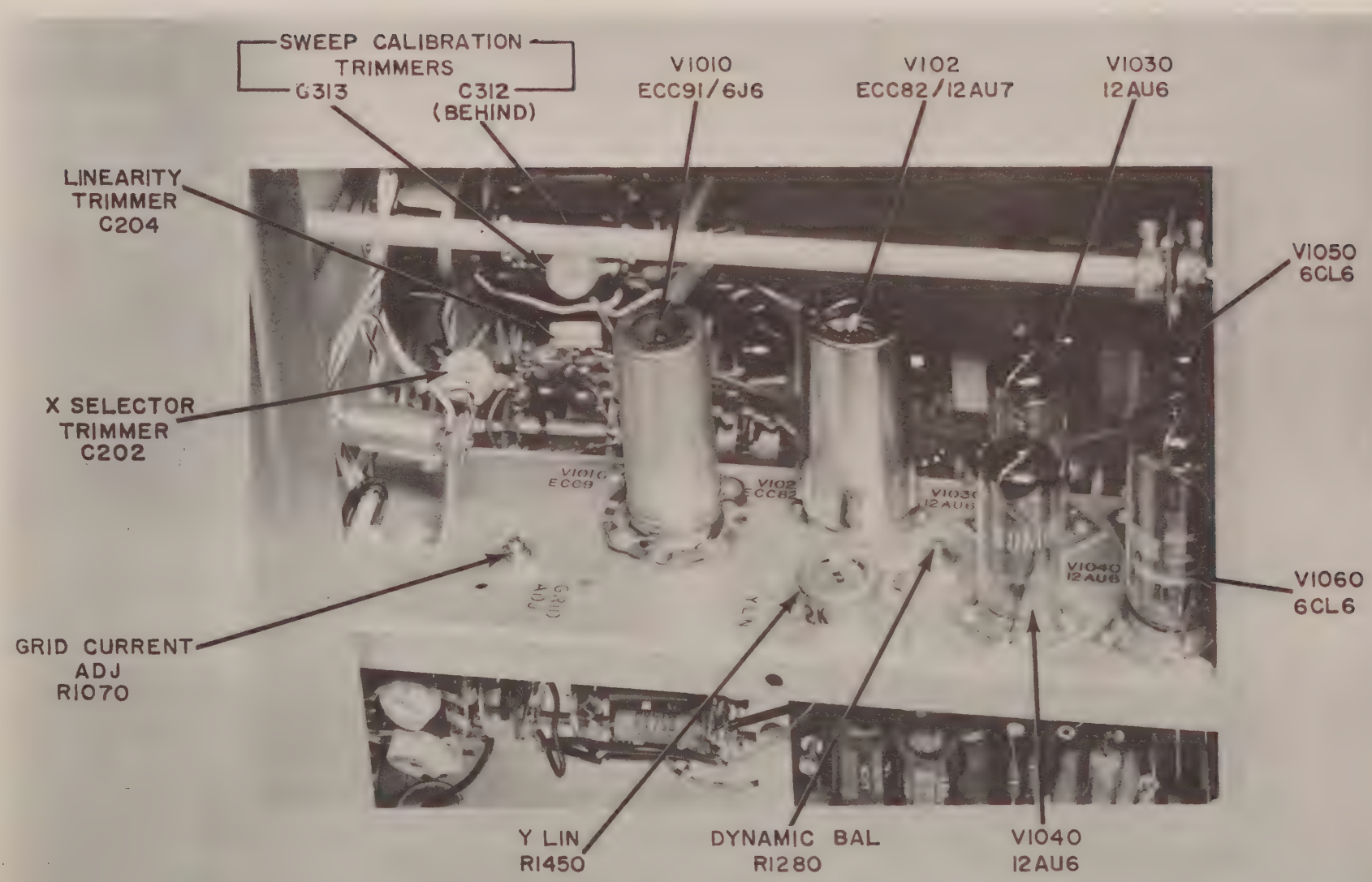


FIGURE 4-4. SERVICE ADJUSTMENTS AND TUBE LOCATIONS - UPPER RIGHT FRONT VIEW.

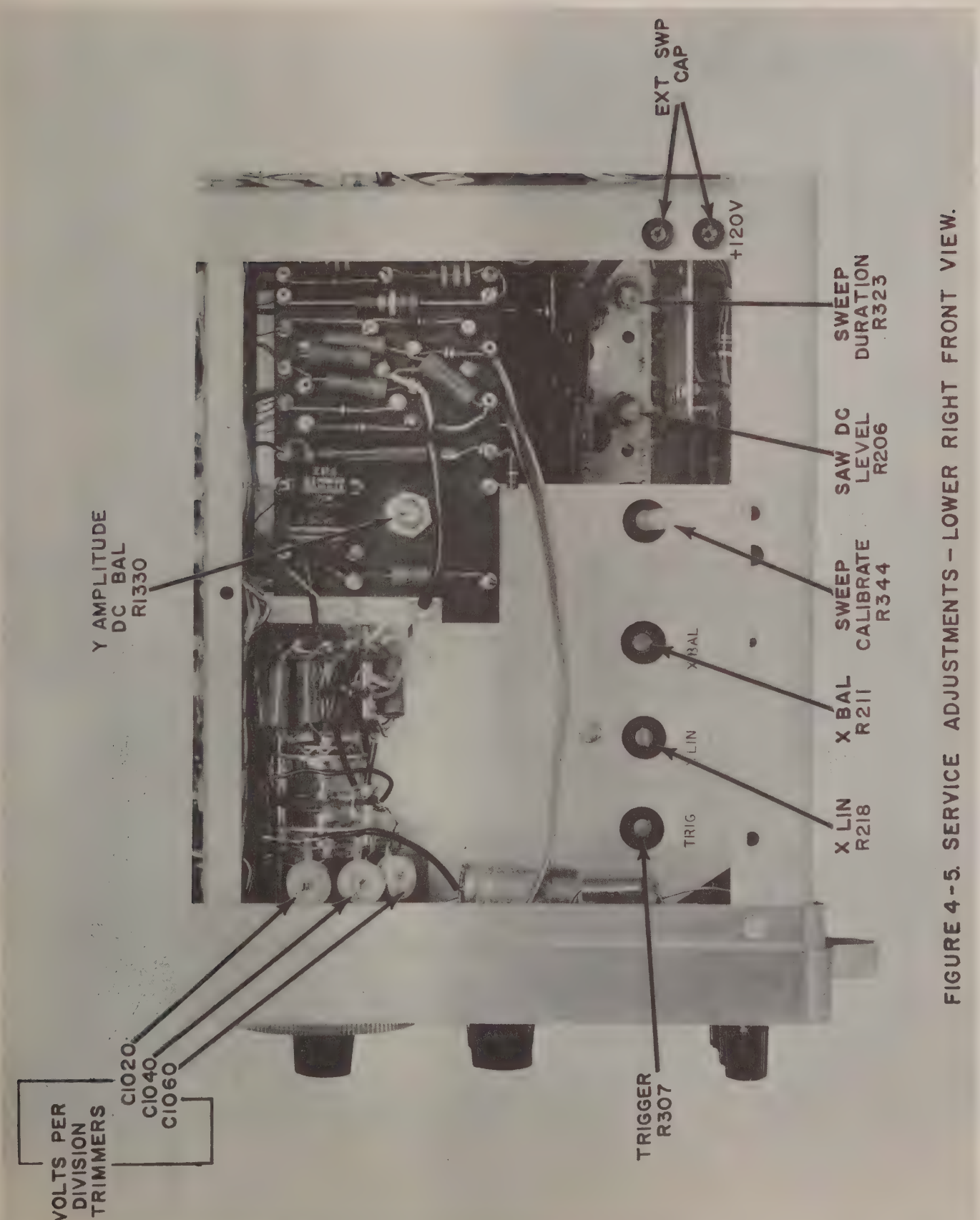


FIGURE 4-5. SERVICE ADJUSTMENTS – LOWER RIGHT FRONT VIEW.

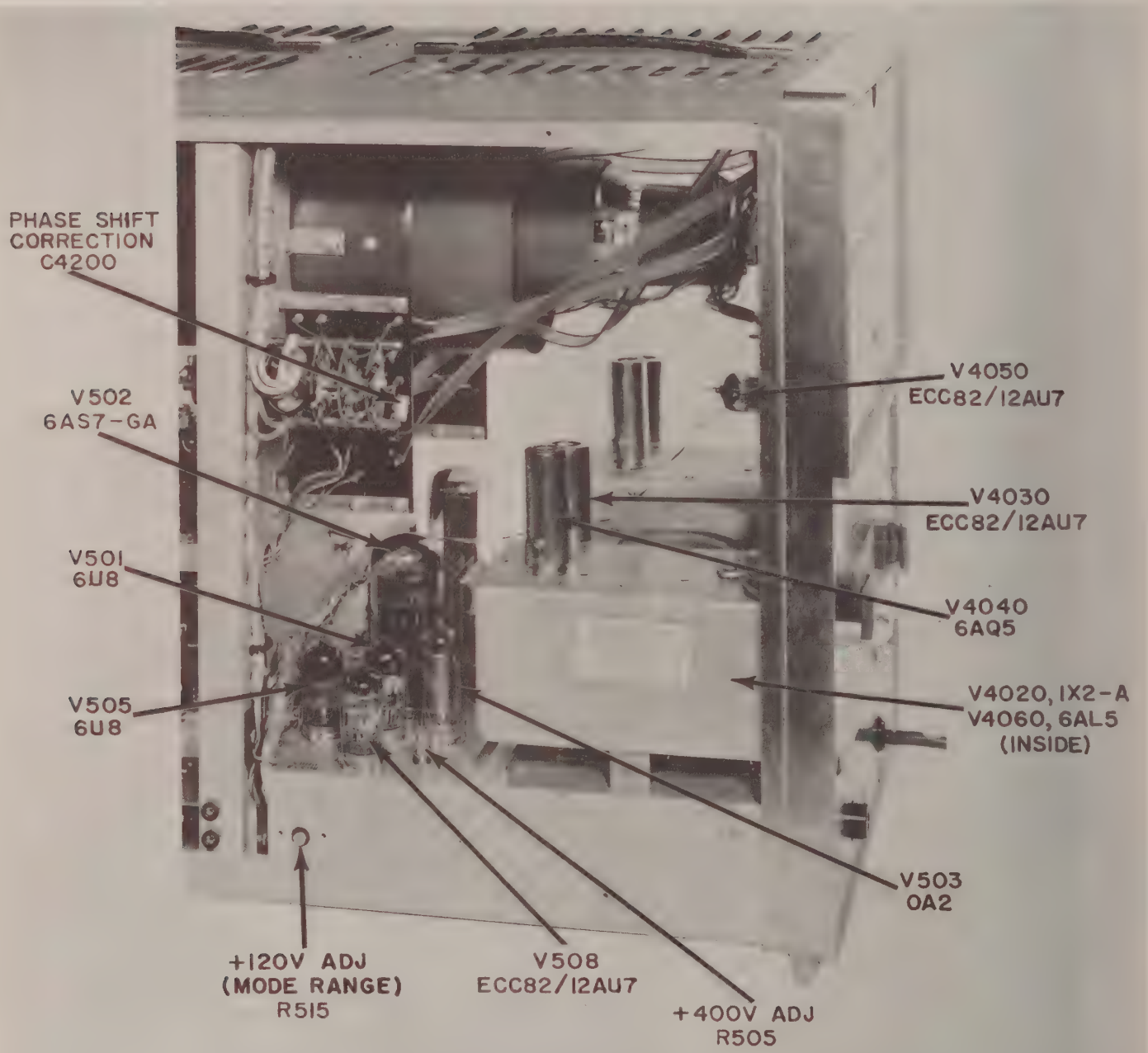


FIGURE 4-6. SERVICE ADJUSTMENTS AND TUBE LOCATIONS - RIGHT REAR CHASSIS.

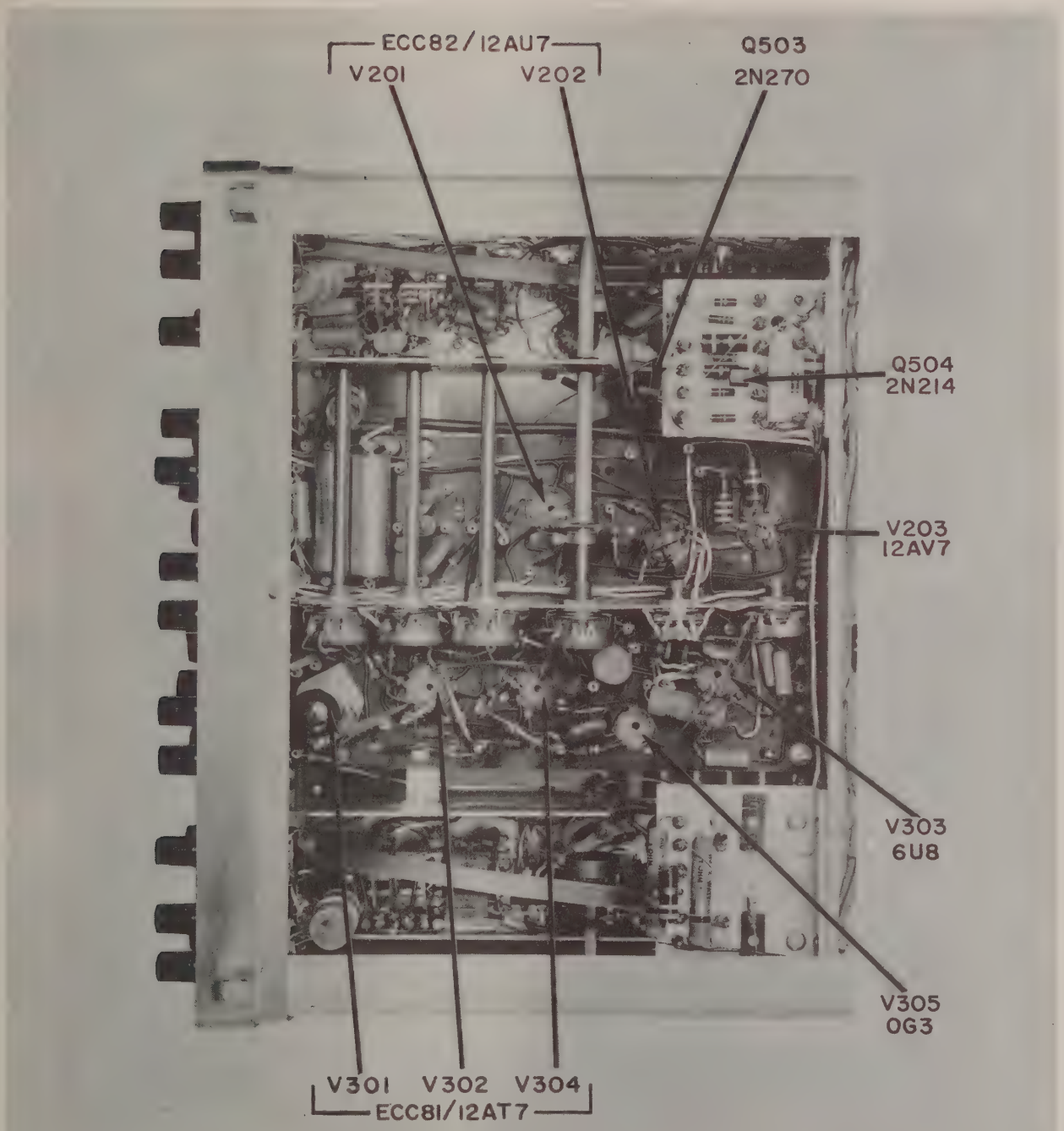


FIGURE 4-7. TRANSISTOR AND TUBE LOCATIONS—BOTTOM FRONT VIEW.

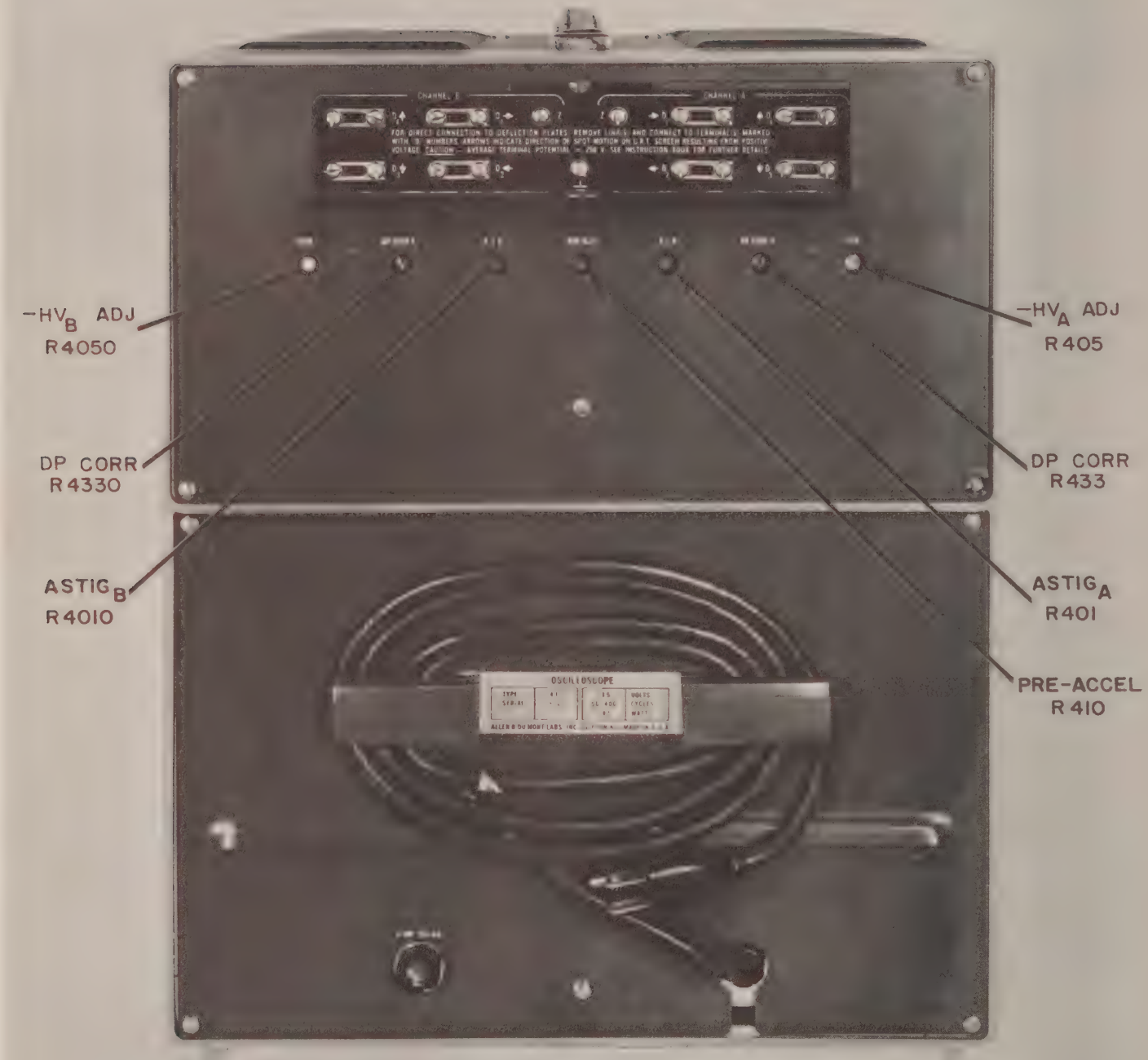


FIGURE 4-8. SERVICE ADJUSTMENTS AND REAR-PANEL FACILITIES.

TABLE 4-3

ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES

SYMBOL	TYPE	SERVICE ADJUSTMENTS TO BE CHECKED (See Table 4-2)
CHANNEL A OR CHANNEL B VERTICAL DEFLECTION AMPLIFIER		
V101/V1010	ECC91/6J6	GRID CURRENT ADJ (R107/R1070) and VOLTS PER DIVISION Capacitors (C102/1020, C104/1040 & C106/1060)
V102/V1020	ECC82/ 12AU7-R	None
V103/V1030 & V104/V1040	12AU6	Y AMPLITUDE DC BAL (R133/R1330)
V105/V1050 & V106/V1060	6AL6	Y LIN (R145/R1450)
HORIZONTAL DEFLECTION AMPLIFIER		
V201	ECC82/ 12AU7	X BAL (R211) and X LIN (R218)
V202	ECC82/ 12AU7	X LIN (R218)
V203	12AV7	None
SYNC AND SWEEP CIRCUITS		
V301 & V302	ECC81/12AT7	TRIGGER (R307) and +120V ADJ (R515)
V303	6U8	TRIGGER (R307) and +120V ADJ (R515)
V304	ECC81/ 12AT7	SWEEP CALIBRATE (R344), C312 & C313
V305	0G3	SWEEP CALIBRATE (R344), C312 & C313

TABLE 4-3. ADJUSTMENTS TO BE MADE WHEN REPLACING TUBES (Contin.)

SYMBOL	TYPE	SERVICE ADJUSTMENTS TO BE CHECKED (See Table 4-2)
CRT, BEAM GATE, AND RF SUPPLY		
V401	5ARP-	SWEEP CALIBRATE (R344), ASTIG (R401/R4010) PRE-ACCEL (R410), DP CORR (R433/4330), and PHASE SHIFT CORRECTION (R420/4200)
V402/V4020	1X2-A	-HV ADJ (R405/R4050 and SWEEP CALIBRATE (R344)
V403/V4030	ECC82/12AU7	See V402/4020
V404/V4040	6AQ5	See V402/V4020
V405/V4050	ECC82/12AU7	See V402/V4020
V406/V4060	6AL5	See V402/V4020
HEATERS AND LOW-VOLTAGE SUPPLY		
V501	6U8	+400V ADJ (R505)
V502	6AS7-GA	+400V ADJ (R505)
V503	OA2	+400V ADJ (R505)
V504	5U4-GB	None
V505	6U8	+120V ADJ (R515)
V506	OG3	None
V507	6AL5	CAL VOLTS (R524/R5240)
V508	ECC82/12AU7	+400V ADJ (R505)

TABLE 4-4

TUBE FAILURE AND ADJUSTMENT MISALIGNMENT CHART

NOTES:
1. This chart tabulates the following information:
   a. Symptoms of tube failure
   b. Symptoms arising from misalignment of service adjustments
2. Some of the symptoms indicated in this chart might be caused by failure of some component associated with the circuit under analysis
3. See Sync and Sweep Schematic for waveform data
4. Channel A and B components are identical in performance. Channel B designation for V101 would be V1010. The Table below tabulates only Channel A components but the information given is equally applicable for Channel B.

SYMPTOMS OF TUBE FAILURE/ADJUSTMENT MISALIGNMENT	REPLACE OR CHECK TUBE/ADJUSTMENT
CHANNEL A OR CHANNEL B VERTICAL DEFLECTION AMPLIFIER	
1a. No vertical deflection	1a. V101 to V106; feel tubes for warmth
2a. Vertical displacement of trace noted when switching VOLTS PER DIVISION control from .01 to .1 AC	2a. GRID CURRENT ADJ (R107)
3a. Vertical shifting of trace noted when switching through ranges of the VOLTS PER DIVISION and (MULTIPLIER) controls	3a. Y MULT BAL (R115) See Section 2, Operation
4a. VOLTS PER DIVISION is set to OFF; trace shifts vertically with changes in setting of Y CAL ADJ	4a. Y AMPLITUDE DC BAL (R133) See Section 2, Operation

TABLE 4-4 TUBE FAILURE AND ADJUSTMENT MISALIGNMENT CHART (Contin.)

SYMPTOMS OF TUBE FAILURE/ADJUSTMENT MISALIGNMENT	REPLACE OR CHECK TUBE/ADJUSTMENT
CHANNEL A OR CHANNEL VERTICAL DEFLECTION AMPLIFIER (Contin.)	
5a. Size of pattern changes as it is positioned vertically on the screen	5a. Y LIN (R145)
6a. Common mode rejection ratio is lower than normal	6a. DYNAMIC BAL (R128)
7a. A 10 Kc square wave signal is distorted at any one range of the VOLTS PER DIVISION switch	7a. VOLTS PER DIVISION Compensation Capacitors (C102, C104, & C106)
HORIZONTAL DEFLECTION AMPLIFIER	
1b. No horizontal deflection; internal sweep circuit is normal	1b. V201 to V203; feel tubes for warmth
2b. X SELECTOR is set to OFF; trace shifts horizontally with changes in setting of X AMPLITUDE control	2b. X BAL (R211)
3b. Sweep fails to expand equally in both directions as X AMPLITUDE is advanced	3b. SAW DC LEVEL (R206)
4b. Size of pattern is distorted when X AMPLITUDE control is rotated fully clockwise	4b. X LIN (R218)
5b. X DISPLAY is set to X AMP/EXP SWP; a 10 Kc square wave signal is distorted when X SELECTOR is set to 10	5b. X SELECTOR Compensation Capacitor (C202)
6b. Non-linearity of the expanded sweep noted at the higher frequencies	6b. Linearity Trimmer (C204)

TABLE 4-4. TUBE FAILURE AND ADJUSTMENT MISALIGNMENT (Contin.)

SYMPTOMS OF TUBE FAILURE/ADJUSTMENT MISALIGNMENT	REPLACE OR CHECK TUBE/ADJUSTMENT
SYNC AND SWEEP CIRCUITS	
1c. No sync; satisfactory waveform at "A", nothing at "B"	1c. V301A
2c. No sync; satisfactory waveform at "B", improper waveforms at "C" and "D"	2c. V301B, V302A, and/or TRIGGER (R307)
3c. No sync; satisfactory waveforms at "C" and "D", nothing at "E"	3c. Series triggering crystal diode, CR301
4c. No sweep; X DISPLAY set to CAL SWP	4c. V302B, V303, and V304; check waveforms "E" through "I"
5c. No sweep; X DISPLAY set to X AMP/EXP SWP	5c. See 1b
6c. X DISPLAY set to CAL SWP; sweep length is less than 10 divisions	6c. SWEEP DURATION (R323)
7c. Approximately one-half of sweep trace is missing; STABILITY is set fully clockwise	7c. V304B
8c. Unstable sweep at low sweep rates	8c. E301 and E302
9c. Over-all sweep rates are out of calibration	9c. SWEEP CALIBRATE (R344), and Trimmers (C312 & C313)
10c. Poor sweep linearity	10c. V302, V304, V305, and/or leaky sweep charging capacitors
11c. Sweep continues to run even after STABILITY is set below the initial sweep starting point	11c. V303; check 185-volt supply

TABLE 4-4. TUBE FAILURE AND ADJUSTMENT MIS-ALIGNMENT CHART (Contin.)

SYMPTOMS OF TUBE FAILURE/ADJUSTMENT MISALIGNMENT	REPLACE OR CHECK TUBE/ADJUSTMENT
SYNC AND SWEEP CIRCUITS (Contin.)	
12c. At low sweep rates, a bright spot at the beginning of trace is noticed	12. See 3d
CHANNEL A OR CHANNEL B BEAM GATE AND RF SUPPLY	
1d. No spot on cathode-ray tube screen	1d. V401 and V402
2d. Poor high-voltage regulation	2d. V403 and V404
3d. Bright spot at left side of screen; visible return trace	3d. V405 and V406
4d. Non-uniform focused pattern as it is positioned over the screen	4d. ASTIG (R401) and PRE-ACCEL (R410)
5d. -HV output is too high or too low	5d. -HV ADJ (R405)
6d. X DISPLAY switches are set up for identical deflection amplifier operation. Phase shifting as a function of frequency is noted on the pattern	6d. Phase Shift Correction (C420)
7d. X DISPLAY switches are set up for calibrated sweep operation; traces do not track horizontally	7d. DP CORR (R433)

TABLE 4-4. TUBE FAILURE AND ADJUSTMENT MISALIGNMENT CHART (Contin.)

SYMPTOMS OF TUBE FAILURE/ADJUSTMENT MISALIGNMENT	REPLACE OR CHECK TUBE/ADJUSTMENT
HEATERS AND LOW-VOLTAGE SUPPLY	
1e. Poor regulation: +185-volt supply	1e. V501A
2e. Poor regulation: +400-volt supply	2e. V501B, V502, V503, and V508
3e. Poor regulation: +150-volt supply	3e. V503
4e. +400-volt supply output is too high or too low	4e. +400V ADJ (R505)
5e. Dead unit; fuse is ok	5e. V504
6e. Poor regulation: +120-volt supply	6e. V505 and V506
7e. +120-volt supply output is too high or too low	7e. +120V ADJ (R515)
8e. Poor regulation: -85-volt supply	8e. V506
9e. No calibrator pattern: (MULTIPLIER) set to CAL	9e. V507; see 1a

TABLE 4-5. VOLTAGE MEASUREMENTS

NOTES:
1. All voltage measurements taken from tube socket to chassis and are dc and positive unless otherwise indicated
2. All measurements taken with a 20,000-ohm/voltmeter unless otherwise indicated
3. *Indicates measurement with VTVM
4. Tube heater voltage measures 6.3 volts ac between pins designated □ and △ ; measures +120 volts with respect to ground unless otherwise indicated

Symbol	Type	1	2	3	4	5	6	7	8	9
					VERTICAL DEFLECTION AMPLIFIER					
					Notes on local measuring conditions a) Set VOLTS PER DIVISION to off b) Set up other front-panel controls for a centered spot c) V105 & V106 voltages vary with Y POSITION and Y LIN (R145) setting					
V101 & V1010	ECC91/6J6	55	55	0	16	0	0	1.4	---	---
V102 & V1020	ECC82/ 12AU7-R	75	55	56	12	12	75	55	56	6
V103 & V1030	12AU6	75	76	0	12	137	165	76	---	---
V104 & V1040	12AU6	75	76	0	12	137	165	76	---	---
V105 & V1050	6CL6	140-150	135-150	210-230	□	△	220-340	140-150	210-230	135-150
V106 & V1060	6CL6	140-150	135-150	210-230	□	△	220-340	140-150	210-230	135-150

TABLE 4-5. VOLTAGE MEASUREMENTS (Contin.)

Symbol	Type	1	2	3	4	5	6	7	8	9
				HORIZONTAL DEFLECTION AMPLIFIER						
	Notes on local measuring conditions a) Set X SELECTOR to OFF b) Set up other front-panel controls for a centered spot c) V202 & V203 voltages vary with X POSITION and X LIN (R218) setting									
V201	ECC82/ 12AU7-Y	400	0	25	□	□	400	0	25	△
V202	ECC82/ 12AU7-Y	50-95	24.5-25	24-29	□	□	50-95	24.5-25	29-85	△
V203	12AV7	160-400	50-95	85-100	□	□	160-400	50-95	85-100	△

TABLE 4-5. VOLTAGE MEASUREMENTS (Contin.)

Symbol	Type	1	2	3	4	5	6	7	8	9
				SYNC AND SWEEP CIRCUITS						
		Notes on local measuring conditions a) Set X DISPLAY to CAL SWP b) Set STABILITY fully counterclockwise and position each spot five centimeters left of center								
V301	ECC81/ 12AT7	107	50	57	□	□	102	6.2*	22	△
V302	ECC81/ 12AT7	114	115	114	□	□	115	50	55	△
V303	6U8	320	115	187	□	△	285	115	115	107
V304	ECC81/ 12AT7	400	115	120	□	□	340	43	49	△
V305	OG3	208	120	208	120	208	120	120	---	--

TABLE 4-5. VOLTAGE MEASUREMENTS (Contin.)

Symbol	Type	1	2	3	4	5	6	7	8	9
					CRT, BEAM GATE, AND RF SUPPLY					
					CAUTION V401, V402, V405, and V406 heaters are connected to the -HV supply					
					Notes on local measuring conditions a) Plate cap of V402 measures -2500 volts with respect to ground b) All V405 and V406 measurements taken with respect to pin 3 or 8 of V405 c) Upper reading of V405 measured with sweep on; lower reading with sweep off					
V401	5ARP-				See schematic for pertinent data					
V402 & V4020	1X2-A	DO	NOT	MEASURE						
V403 & V4030	ECC82/ 12AU7-R	115	-1.5*	---	□HV	HV	73	-1.5*	---	△HV
V404 & V4040	6AQ5	-130*	0	□HV	△HV	400	75	-130*	---	---
V405 & V4050	ECC82/ 12AU7-R	60 65	-16 0	0 0	□HV □HV	□HV □HV	55 69	-14 -18	0 0	△HV △HV
V406 & V4060	6AL5	115	-120	□HV	△HV	DO		NOT		MEASURE

TABLE 4-5. VOLTAGE MEASUREMENTS (Contin.)

Symbol	Type	1	2	3	4	5	6	7	8	9
					HEATER AND LOW-VOLTAGE SUPPLY					
					Note: V504 heater measures 5 volts ac across pins 2 and 8					
V501	6U8	400	148	280	□	△	340	150	192	178
V502	6AS7-GA	340	540	400	340	540	400	□	△	---
V503	0A2	150	0	---	0	150	---	0	---	---
V504	5U4-GB	---	540	---	450 ac	---	450 ac	---	540	---
V505	6U8	400	-4*	115	□	△	105	0	115	105
V506	OG3	0	-85	---	-85	0	---	-85	---	---
V507	6AL5	150	0	□	△	60	0	60	---	---
V508	ECC82/ 12AU7	148	0	3	□	□	150	0	3	△

TRANSISTORS

Note: All voltage measurements taken with respect to chassis and are dc and positive unless otherwise indicated

Symbol	Type	Emitter	Base	Collector
Q501 & Q502	2N301	15.9	15.2	12
Q503	2N270	15.2	15.0	12
Q504	2N214	0.78	0.9	8.0

TABLE 4-6. RESISTANCE MEASUREMENTS

NOTES:
1. All resistance measurements taken from tube socket to chassis unless otherwise indicated
2. All resistance measurements are in ohms; K = thousand, M = million
3. Do not take readings immediately after turning off equipment

Symbol	Type	1	2	3	4	5	6	7	8	9
		VERTICAL DEFLECTION AMPLIFIER Note: Set VOLTS PER DIVISION to OFF and MULTIPLIER to X1								
V101 & V1010	ECC91/6J6	Inf	Inf	0	1.2	100K	100K	200K	---	---
V102 & V1020	ECC82/ 12AU-R	65K	28K	Inf	0	2.4	65K	28K	Inf	4.4
V103 & V1030	12AU6	65K	9100	0	2.4	42K	36K	9100	---	---
V104 & V1040	12AU6	65K	9100	0	2.4	42K	36K	9100	---	---
V105 & V1050	6CL6	7500-10K	42K	95K	15K	15K	50K	7500-10K	95K	42K
V106 & V1060	6CL6	7500-10K	42K	95K	15K	15K	50K	7500-10K	95K	42K

TABLE 4-6. RESISTANCE MEASUREMENTS (Contin.)

Symbol	Type	1	2	3	4	5	6	7	8	9
	HORIZONTAL DEFLECTION AMPLIFIER									
	Note: Set X SELECTOR to OFF									
V201	ECC82/ 12AU7-Y	36K	100	5-8	15K	15K	36K	100	5-8	15K
V202	ECC82/ 12AU7-Y	100K	8K	2.8-4.2	15K	15K	100K	8K	2.8-4.2	15K
V203	12AV7	68K	100K	12K	15K	15K	68K	100K	12K	15K

TABLE 4-6. RESISTANCE MEASUREMENTS (Contin.)

Symbol	Type	1	2	3	4	5	6	7	8	9
				SYNC AND SWEEP CIRCUITS						
		Note: Set SWEEP(MULTIPLIER) to X1								
V301	ECC81/ 12AT7	19K	390K	39K	15K	15K	22K	2.2M	12K	15K
V302	ECC81/ 12AT7	260K	65K	15K	15K	15K	16K	50K	38K	15K
V303	6U8	50K	98K	Inf	15K	15K	45K	6500	6500	33K
V304	ECC81/ 12AT7	36K	26K	18.5K	15K	15K	Inf	Inf	Inf	15K
V305	OG3	87K	18K	87K	87K	87K	Inf	Inf	18K	---

TABLE 4-6. RESISTANCE MEASUREMENTS (Contin.)

Symbol	Type	1	2	3	4	5	6	7	8	9
					CRT, BEAM GATE, AND RF SUPPLY					
		Notes: a) Plate cap of V402 measures 8 megohms b) All V405 and V406 measurements taken with respect to pin 2 of V406								
V401	5ARP-	See schematic for pertinent data								
V402 & V4020	1X2-A	Resistance of pins 1 through 9 measure approximately 80 ohms								
V403 & V4030	ECC82/ 12AU7-R	675K	1.4	0	15K	15K	90K	78K	0	15K
V404 & V4040	6AQ5	130K	0	15K	15K	37K	100K	130K	---	---
V405 & V4050	ECC82 12AU7-R	270K	340K	Inf	175K	175K	280K	350K	Inf	175K
V406 & V4060	6AL5	220K	0	175K	175K	Inf	---	Inf	---	---

TABLE 4-6. RESISTANCE MEASUREMENTS (Contin.)

Symbol	Type	1	2	3	4	5	6	7	8	9
		HEATER AND LOW-VOLTAGE SUPPLY								
		CAUTION: Do not make any resistance measurements on the transistor voltage regulator								
V501	6U8	36K	225K	100K	15K	15K	350K	38K	Inf	200K
V502	6AS7-GA	350K	150K	36K	350K	150K	36K	15K	15K	---
V503	OA2	38K	0	---	0	38K	---	0	---	---
V504	5U4-GB	---	150K	---	60	---	60	---	150K	---
V505	6U8	38K	240K	15K	15K	15K	500K	0	15K	500K
V506	OG3	0	150K	---	150K	0	---	150K	---	---
V507	6AL5	35K	0	15K	15K	1.8M	0	1.8M	---	---
V508	ECC82/ 12AU7	225K	0	2700	15K	15K	38K	520K	2700	15K

SECTION 5

ELECTRICAL PARTS LIST AND SCHEMATICS

TYPE 411 AND 411-R OSCILLOSCOPES

Symbol Numbering System

100 Series - Vertical Deflection Amplifier
200 Series - Horizontal Deflection Amplifier
300 Series - Sync And Sweep Circuits
400 Series - CRT, Beam Gate, And RF Supply
500 Series - Heaters And Low-Voltage Supply

Symbol	Part Number	Description
		CAPACITORS (All capacitors are fixed, ceramic, ±5%, 500 V unless otherwise specified)
		VERTICAL DEFLECTION AMPLIFIER
C101/C1010	0318 1140	paper, 0.1 uf, +20 -10%, 1000 V
C102/C1020	0312 8420	variable, 5-25 uuf, 350 V
C103/C1030	0305 5170	mica, 100 uuf
C104/C1040	0312 8420	variable, 5-25 uuf, 350 V
C105/C1050	0302 2010	mica, 1000 uuf, 300 V
C106/C1060	0312 8420	variable, 5-25 uuf, 350 V
C107/C1070	0303 3380	mica, 6800 uuf, 300 V
C108/C1080	0315 4620	1000 uuf, ±10%, 1000 V
C109/C1090	0313 7840	0.01uf, ±20 uuf
C111/C1110	0305 5010	mica, 22 uuf
C112/C1120	0313 7840	0.01 uf, ±20 uuf
C113/C1130	0313 8780	electrolytic, 8 uf, +100 -10%, 150 V
C114/C1140	0316 6750	2700 uuf, ±20%
		HORIZONTAL DEFLECTION AMPLIFIER
C201	0301 7460	paper, 0.1 uf, ±20%, 600 V
C202	0312 8420	variable, 5-25 uuf, 350 V
C203	0305 5170	mica, 100 uuf
C204	0312 8420	variable, 5-25 uuf, 350 V
C205	0305 5170	mica, 100 uuf

Symbol	Part Number	Description
C206 & C207	0313 3900	composition, 3.3 uuf, ±10%
C210	0305 5370	mica, 10 uuf
	SYNC AND SWEEP CIRCUITS	
C301	0313 9610	0.02 uf, +100 -0%, 450 V
C303 & C304	0313 8390	paper, 0.33 uf, ±10%, 100 V
C305	0305 5010	mica, 22 uuf
C306	0305 5010	mica, 22 uuf
C307	0313 9610	0.02 uf, +100 -0%, 450 V
C308	0313 3930	composition, 5.6 uuf, ±10%
C309	0313 9610	0.02 uf, +100 -0%, 450 V
C310	0319 0891	electrolytic, 1 uf, 250 V
C311	0313 3470	composition, 0.68 uuf
C312	0312 8400	variable, 1.5-7 uuf, 350 V
C313	0312 8420	variable, 5-25 uuf, 350 V
C314	0305 5220	mica, 160 uuf
C315	0316 1530	mica, 1980 uuf, ±1%
C316	0312 5670	assembly, paper, 0.02 uf, ±1%, 200 V
C317	0312 5681	assembly, paper, 0.2 uf, ±1%, 200 V
C318	0312 5691	assembly, paper, 2 uf, ±1%, 200 V
C319	0313 9610	0.02 uf, +100 -0%, 450 V
C321 & C322	0313 9610	0.02 uf, +100 -0%, 450 V
C323	0305 5250	mica, 220 uuf
C324	0313 9610	0.02 uf, +100 -0%, 450 V
	CRT, BEAM GATE, AND RF SUPPLY	
C401/C4010	0313 9610	0.02 uf, +100 -0%, 450 V
C402/C4020	0316 9870	5000 uuf, +100 -0%, 3000 V
C403/C4030	0316 9870	5000 uuf, +100 -0%, 3000 V
C404/C4040	0316 9080	470 uuf, ±20%, 4000 V
C405/C4050	0316 9870	5000 uuf, +100 -0%, 3000 V
C406/C4060	0316 9870	5000 uuf, +100 -0%, 3000 V
C407/C4070	0316 9870	5000 uuf, +100 -0%, 3000 V
C408/C4080	0316 9870	5000 uuf, +100 -0%, 3000 V
C409A,B/ C4090A,B	0311 6740	paper, 25 uf/25 uf, +20 -10%, 600 V

Symbol	Part Number	Description
C410	0313 9610	0.02 uf, +100 -0%, 450 V
C411/C4110	0302 2010	mica, 1000 uuf, 300 V
C412/C4120	0314 6090	1.5 uuf, ±0.5 uuf, 5000 V
C413/C4130	0319 1615	paper, 0.1 uf, ±20%, 400 V
C414/C4140	0319 1615	paper, 0.1 uf, ±20%, 400 V
C415/C4150	0319 1615	paper, 0.1 uf, ±20%, 400 V
C416/C4160	0305 5720	mica, 1980 uuf, ±1%, 500 V
C417/C4170	0313 9610	0.02 uf, +100 -0%, 450 V
C420/C4200	0312 8420	variable, 5-25 uuf, 350 V
	HEATERS AND LOW-VOLTAGE SUPPLY	
C501 A,B,C	0316 9680	electrolytic, 20 uf/40 uf/10 uf, +40 -10%, 450 V/250 V/250V
C502	0319 1688	paper, 0.22 uf, ±20%, 600 V
C503	0313 9610	0.02 uf, +100 -0%, 450 V
C504	0315 4620	1000 uuf, ±10%, 1000 V
C505	0301 4460	electrolytic, 125 uf, +50 -10%, 350 V
C507	0313 9610	0.02 uf, +100 -0%, 450 V
C508	0319 1615	paper, 0.1 uf, ±20%, 400 V
C509 & C510	0317 8450	electrolytic, 100 uf, 250 V
C511	0313 9610	0.02 uf, +100 -0%, 450 V
C512	0316 6350	electrolytic, 3000 uf, +250 -10%, 25 V
C513	0318 0250	plastic, .47 uf, ±20%, 150 V
	SEMICONDUCTORS	
CR301 to CR303	2600 1220	IN69
CR504	2600 6400	Zener diode, silicon, 11 V, ±5%, 1 W
	RECTIFIERS (Metallic)	
CR501 & CR502	2600 5000	selenium, single phase, 1/2 wave, 50 ma dc
CR503	2600 1880	selenium, single phase, full wave bridge, 3 amperes dc

Symbol	Part Number	Description
		LAMPS
DS401/DS4010	1200 1370	incandescent, miniature bayonet, 250 ma, 6.3 V
DS501 to DS504	1201 0960	incandescent, miniature bayonet, 160 ma, 6.3 V
DS505	1200 1370	incandescent, miniature bayonet, 250 ma, 6.3 V
		NEON REGULATORS
E301 & E302	1200 8931	lamp, glow
E401/E4010	1200 8931	lamp, glow
		FUSES
F501	1100 1050	4 amperes, slow blow (115-volt operation)
	1100 0990	2 amperes, slow blow (230-volt operation)
		CONNECTORS
J101/J1010	5101 2551	post, binding, black
J102/J1020	5101 2551	post, binding, black
J103/J1030	5101 2551	post, binding, black
J201 & J202	5101 2551	post, binding, black
J301 to J304	5101 2551	post, binding, black
- - -	0905 5140	adapter, line plug; 3-wire power connector to 2-prong female receptacle
		COILS
L301	2101 3000	fixed, 47 mh
L401/4010	2100 3800	fixed, 6.8 mh, ±5%, universal winding
		TRANSISTORS
Q501 & Q502	2600 6280	2N301, PNP
Q503	2600 6390	2N270, PNP
Q504	2600 6290	2N214, NPN

Symbol	Part Number	Description
		RESISTORS (Resistance values in ohms; K = thousand, M = million. All resistors are fixed, composition, ±10%, & 1/2 watt unless otherwise specified)
		VERTICAL DEFLECTION AMPLIFIER
R101/R1010	0228 6230	film, 2M, ±1%
R102/R1020	0228 6020	film, 250K, ±1%
R103/R1030	0228 5760	film 20,400, ±1%
R104/R1040	0228 5520	film, 2K, ±1%
R105/R1050	0228 6230	film, 2M, ±1%
R106/R1060	0228 6230	film, 2M, ±1%
R107/R1070	0107 5900	variable, 100, ±20%
R108/R1080	0203 2170	2.2M
R109/R1090	0203 2010	100K
R110/R1100	0203 6870	43K, ±5%, 2 W
R111/R1110	0203 2010	100K
R112/R1120	0228 5830	film, 47K, ±1%
R113/R1130	0228 5560	film 5600, ±1%
R114/R1140	0228 5810	film, 39K, ±1%
R115A,B/ R1150A,B	0107 1672	variable, 15K/2K, ±20%
R116/R1160	0228 5760	film, 20,400, ±1%
R117/R1170	0222 0000	wire wound, 55,750, ±1%, 3/4 W
R118/R1180	0222 0000	wire wound, 55,750, ±1%, 3/4 W
R119/R1190	0228 5660	film, 10,300, ±1%
R120/R1200	0203 0680	6800, ±5%
R121/R1210	0228 5620	film, 9300, ±1%
R122/R1220	0228 5540	film, 3100, ±1%
R123/R1230	0228 5500	film, 1030, ±1%
R124/R1240	0228 5870	film, 93K, ±1%
R125/R1250	0228 5790	film, 31K, ±1%
R126/R1260	0228 5660	film, 10,300, ±1%
R127/R1270	0203 2150	1.5M
R128/R1280	0107 4430	variable, 5M, ±20%
R129/R1290	0203 2150	1.5M

Symbol	Part Number	Description
R130/R1300	0107 1681	variable, 2500, ±20%, 1/4 W
R131/R1310	0108 0900	variable, 2500, 1/5 W
R132/R1320	0203 1760	820
R133/R1330	0107 2230	variable, 250, 1/4 W
R134/R1340	0203 1760	820
R135/R1350	0230 4620	wire wound, 9100, ±5%, 3 W
R136/R1360	0228 5710	film 15K, ± 1%
R137/R1370	0228 5710	film 15K, ±1%
R138/R1380	0203 2030	150K
R139/R1390	0100 8180	variable, 500K, ±20%, 1/4 W
R140/R1400	0228 5590	film, 7250, ±1%
R141/R1410	0203 2030	150K
R142/R1420	0203 0260	120
R143/R1430	0203 0260	120
R144/R1440	0230 4600	wire wound, 6800, ±5%, 3 W
R145/R1450	0107 4750	variable, wire wound, 2K, ±20%, 1-1/2 W
R146/R1460	0203 6910	62K, ±5%, 2 W
R147/R1470	0210 9360	wire wound, 20K, ±5%, 5 W
R148/R1480	0203 6680	6800, ±5%, 2 W
R149/R1490	0203 6750	13K, ±5%, 2 W
R152/R1520	0203 2170	2.2M
R153/R1530	0203 2170	2.2M

HORIZONTAL DEFLECTION AMPLIFIER

R201	0204 1270	2M, ±5%
R202	0204 1040	220K ±5%
R203	0204 1270	2M, ±5%
R204	0203 1170	750K, ±5%
R205	0203 1150	620K, ±5%
R206	0105 6330	variable, 250K, ±20%, 1/4 W
R207 & R208	0203 1650	100
R209	0203 0690	7500, ±5%
R211	0107 1591	variable, 5K, ±20%, 2 W
R212	0203 0690	7500, ±5%

Symbol	Part Number	Description
R213	0100 8160	variable, 10K, ±20%, 1/4 W
R214	0203 1740	560
R215	0203 1650	100
R216	0107 6830	variable, 1500, ±20%, 1/4 W
R217	0203 0640	4700, ±5%
R218	0108 3070	variable, 10K, ±20%, 2 W
R219	0203 0830	30K, ±5%
R220	0203 0900	56K, ±5%
R221	0203 6860	39K, ±5%, 2 W
R222	0203 0830	30K, ±5%
R223	0203 6720	10K, ±5%, 2 W
R224 & R225	0203 6840	33K, ±5%, 2 W

SYNC AND SWEEP CIRCUITS

R301	0203 2170	2.2M
R302	0203 0740	12K, ±5%
R303	0203 1800	1800
R304	0203 0720	10K, ±5%
R305	0100 8170	variable, 200K, 1/4 W
R306	0203 0800	22K, ±5%
R307	0108 3070	variable, 10K, ±20%, 2 W
R308	0203 0800	22K, ±5%
R309	0203 2080	390K
R311	0203 0640	4700, ± 5%
R312 & R313	0203 0960	100K, ±5%
R314	0203 0860	39K, ±5%
R315	0203 1800	1800
R316	0228 5870	film, 30K, ±1%
R317	0228 5970	film, 180K, ±1%
R318A,B	0105 8391	variable, 50K/25K, ±20% (part of switch assembly, S201)
R319	0228 6080	film, 560K, ±1%
R321	0210 9360	wire wound, 20K, ±5%, 5 W
R322	0228 6040	film, 270K, ±1%
R323	0105 6330	variable, 250K, ±20%, 1/4 W
R324	0203 1070	300K, ±5%

Symbol	Part Number	Description
R325	0228 5970	film, 180K, ±1%
R326	0222 5020	wire wound, 10K, ±5%, 5 W
R327	0203 2170	2.2M
R328	0203 1650	100
R329	0203 1740	560
R331	0203 6720	10K, ±5%, 2 W
R332	0228 6040	film, 270K, ±5%, 5 W
R323	0105 6330	variable, 250K, ±20%, 1/4 W
R324	0203 1070	300K, ±5%
R325	0228 5970	film, 180K, ±1%
R326	0222 5020	wire wound, 10K, ±5%, 5 W
R327	0203 2170	2.2M
R328	0203 1650	100
R329	0203 1740	560
R331	0203 6720	10K, ±5%, 2 W
R332	0228 6060	film, 450K, ±1%
R333	0203 3900	56K, ±5%, 1 W
R334	0228 6160	film, 900K, ±1%
R335	0228 6180	film, 1.35M, ±1%
R336	0228 6240	film, 2.25M, ±1%
R337	0107 6810	variable, 5M, ±20%, 1/4 W
R338	0203 1110	430K, ±5%
R339 & R340	0203 1650	100
R341	0203 6750	13K, ±5%, 2 W
R342	0203 3680	6800, ±5%, 1 W
R343	0203 1650	100
R344	0108 3250	variable, 25K, ±20%, 2 W
R345	0203 6780	18K, ±5%, 2 W
R346	0203 0800	22K, ±5%
R347	0203 0720	10K, ±5%
R348	0203 0800	22K, ±5%
R349	0203 2080	390K
R350	0100 8140	variable, 1M, ±20%. 1/4 W
R351	0203 1610	47
R352	0203 2100	560K

Symbol	Part Number	Description
		CRT, BEAM GATE, AND RF SUPPLY
R401/R4010	0100 9080	variable, 250K, ±20%, 2 W
R402/R4020	0203 2170	2.2M
R403/R4030	0203 0860	39K, ±5%
R404/R4040	0228 6150	film, 1M, ±1%
R405/R4050	0103 3340	variable, 1M, ±20%, 2 W
R406/R4060	0228 6790	film, 1.8M, ±1%, 1 W
R407/R4070	0228 6790	film, 1.8M, ±1%, 1 W
R408/R4080	0228 6790	film, 1.8M, ±1%, 1 W
R409/R4090	0107 1373	variable, 1.5M, ±20%
R410	0100 9080	variable, 250K, ±20%. 2 W
R411/R4110	0210 0810	wire wound, 4.7
R412/R4120	0203 2130	1M
R413/R4130	0203 2090	470K
R414/R4140	0203 1250	1.6M, ±5%
R415/R4150	0203 8020	120K, 2 W
R416/R4160	0203 8020	120K, 2 W
R417/R4170	0203 2030	150K
R418/R4180	0203 2010	100K
R419/R4190	0203 1070	300K, ±5%
R421/R4210	0203 1070	300K, ±5%
R422/R4220	0203 2010	100K
R423/R4230	0107 1371	variable, 250K, ±20%
R424/R4240	0203 2110	680K
R425/R4250	0203 2110	680K
R426/R4260	0203 2030	150K
R427/R4270	0203 2170	2.2M
R428/R4280	0203 2170	2.2M
R429/R4290	0203 2170	2.2M
R430/R4300	0203 1170	750K, ±5%
R431/R4310	0203 2170	2.2M
R432/R4320	0203 2130	1M
R433/R4330	0100 9080	variable, 250K, ±20%, 2 W
R434/R4340	0203 1150	620K, ±5%

Symbol	Part Number	Description
		HEATER AND LOW VOLTAGE SUPPLY
R501 & R502	0203 3160	47, ±5%, 1 W
R503	0228 6200	film, 1.2M, ±1%
R504	0228 6160	film, 1.2M, ±1%
R505	0103 3300	variable, 50K, ±20%. 2 W
R506	0203 2090	470K
R507	0228 6080	film, 560K, ±1%
R508	0210 8050	wire wound, 12K, ±5%, 10 W
R509	0203 2050	220K
R510	0203 8020	120K, 2 W
R511	0203 3940	82K, ±5%, 1 W
R512 & R513	0203 5050	220K, 1 W
R514	0228 6000	film, 240K, ±1%
R515	0103 3300	variable, 50K, ±20%, 2 W
R516	0203 2010	100K
R517	0228 5950	film, 160K, ±1%
R518	0203 2090	470K
R519 & R520	0203 6580	2700, ±5%, 2 W
R521	0203 3160	47, ±5%, 1 W
R523/R5230	0228 6300	film, 5M, ±1%
R524/R5240	0101 4840	variable, 10K, ±20%, 2 W
R525/R5250	0228 ~~5690~~ 5560	film ~~13K~~, 5600Ω, ±1%
R526	0203 8180	2.7M, 2 W
R527	0203 2050	220K
R528	0203 1820	2700
R529	0107 1632	variable, wire wound, 50, 2 W
R531	0210 7960	wire wound, 5K, ±5%, 10 W
R532	0203 3460	820, ±5%, 1 W
R533	0203 0200	68, ±5%
R534	0203 6090	24, ±5%, 2 W
R535	0203 0720	10K, ±5%
R536	0203 0780	18K, ±5%
R537	0203 0720	10K, ±5%
R538	0203 0950	91K, ±5%
R539	0203 0640	4700, ±5%
R541 & R542	0210 4710	wire wound, 1, ±5%, 2 W
R543	0203 0250	100, ±5%
R544 & R545	0203 6150	43, ±5%, 2 W

Symbol	Part Number	Description
	SWITCHES	(All rotary switches are phenolic and the angle of throw is 30° between positions unless otherwise specified)
S101/S1010	0501 3041	assembly, rotary; 3 decks, 11 positions; 3 decks, 7 positions
S102/S1020	0501 3041	assembly, rotary, 3 decks, 11 positions; 3 decks, 7 positions
S201	0501 3312	rotary, 3 decks, 6 positions
---	0501 3311	assembly, consist of S201 and R318
S301	0501 3301	rotary, 60°, 1 deck 4 positions
S302 & S303	0501 2581	assembly, rotary; 2 decks 6 positions; 1 deck 5 positions
S401/S4010	0501 3291	rotary, 60°, 3 decks, 4 positions toggle, SPST
	TRANSFORMERS	
T401/T4010	2000 7231	radio frequency, high voltage
T501	2001 1622	power, low voltage, 115/230 volts, ±10%, 50-400 cycles/second

Symbol	Part Number	Description
	TUBES	
V101/V1010	2501 1620	ECC91/6J6
V102/V1020	2501 1610	ECC82/12AU7 (yellow tip)
V103/V1030	2500 9110	12AU6
V104/V1040	2500 9110	12AU6
V105/V1050	2500 7820	6CL6
V106/V1060	2500 7820	6CL6
V201 & V202	2501 1610	ECC82/12AU7 (yellow tip)
V203	2500 8220	12AV7
V301 & V302	2501 1690	ECC81/12AT7
V303	2500 7310	6U8
V304	2501 1690	ECC81/12AT7
V305	2500 9270	0G3
V401*	2500 9600	5ARP1
	2500 9610	5ARP2
	2500 9620	5ARP7
	2500 9630	5ARP11
	*Depending on sales order	
V402/V4020	2500 6490	1X2-A
V403/V4030	2501 1610	ECC82/12AU7 (yellow tip)
V404/V4040	2500 0340	6AQ5
V405/V4050	2501 1610	ECC82/12AU7 (yellow tip)
V406/V4060	2500 0020	6AL5
V501	2500 7310	6U8
V502	2501 0200	6AS7-GA
V503	2500 0300	0A2
V504	2500 9320	5U4-GB
V505	2500 7310	6U8
V506	2500 9270	0G3
V507	2500 0020	6AL5
V508	2501 1610	ECC82/12AU7 (yellow tip)
	CABLE	
W501	5026 9641	assembly, power, electrical, 3-conductor, #18 AWG, 72 inches

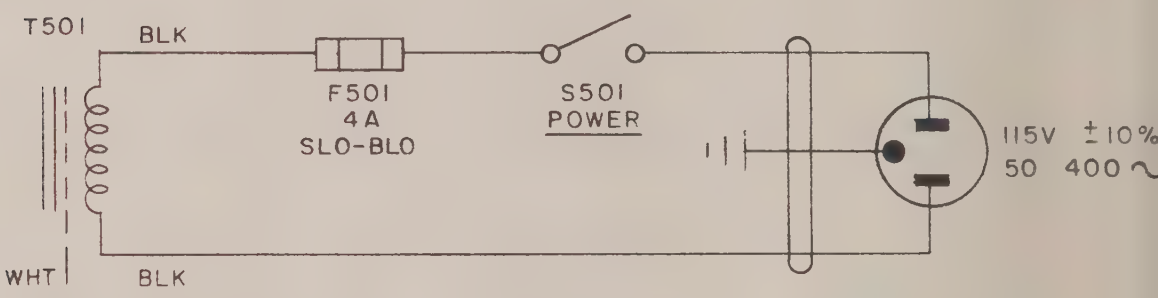
APPENDIX

Two regulated power supplies are available from the following power sources:

a. 50 to 400 cycles per second line at either 115 volts, ±10%, or 230 volts, ±10%. This is the circuit shown on Sheet 5 of Schematic Drawing 9800 1531-4.

b. 50 to 400 cycles per second line at 115 volts, ±10%.

c. On Sheet 5 of Schematic 9800 1531-4, the primary circuit for paragraph b above is revised as follows:



d. The Parts List addition for paragraph b is as follows:

	Symbol	Part Number	Description
Add	F501	1100 1050	Fuse, 4 amperes, slow blow
Add	T501	2001 1621	Transformer, power, low voltage, 115 volts, ±10%, 50-400 cycles/sec

CHANNEL A OR CHANNEL B VERTICAL DEFLECTION AMPLIFIER (NOTE 8)

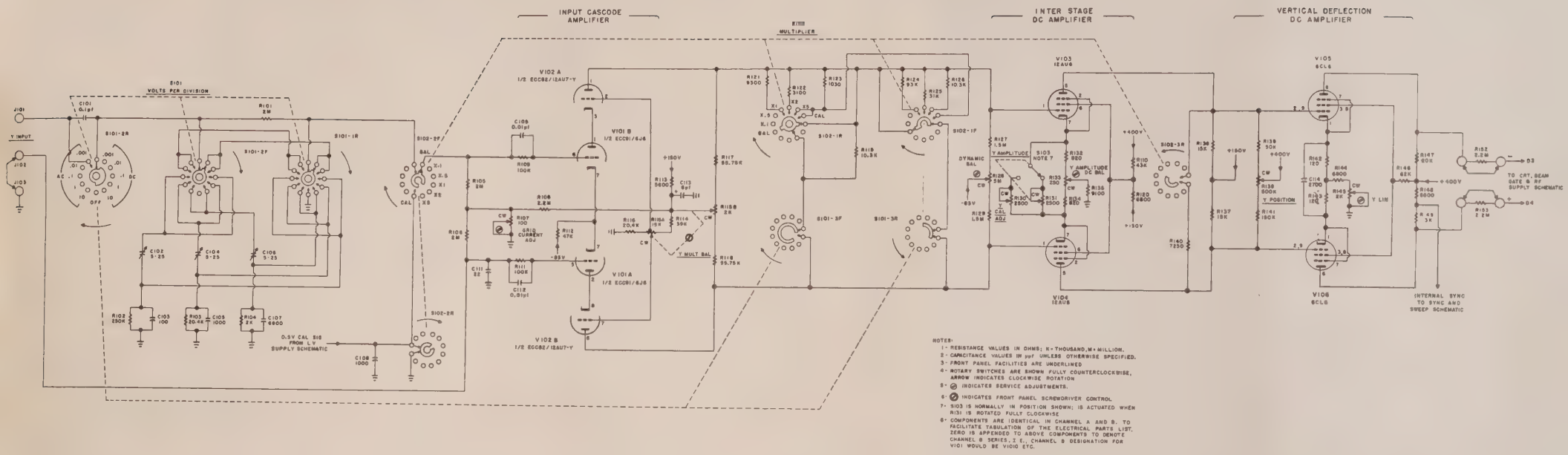
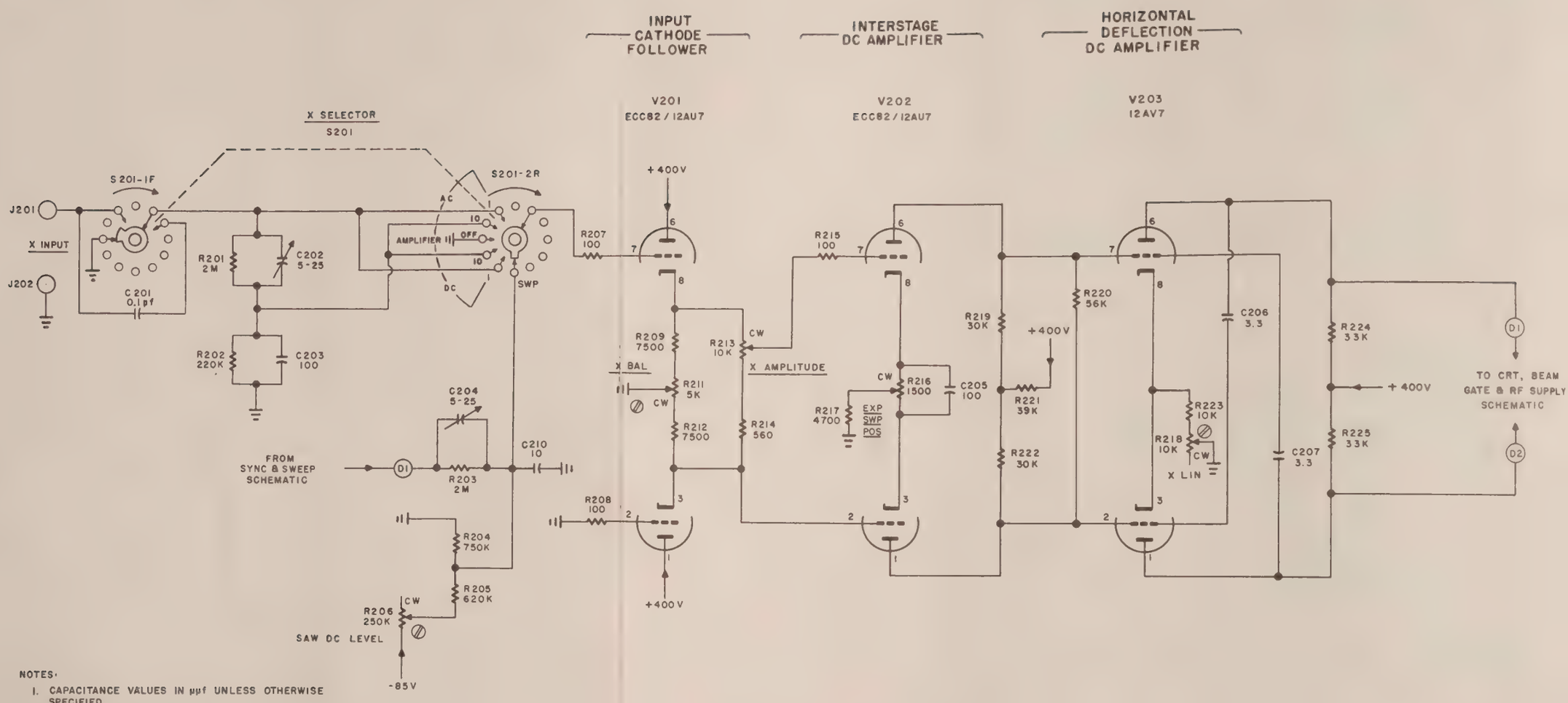

INPUT CASCODE AMPLIFIER
INTER STAGE DC AMPLIFIER
VERTICAL DEFLECTION DC AMPLIFIER
S101 VOLTS PER DIVISION
J101
Y INPUT
J102
J103
V102 A 1/2 ECC82/12AU7-Y
V102 B 1/2 ECC82/12AU7-Y
V101 B 1/2 ECC81/6J8
V101 A 1/2 ECC81/6J8
V103 12AU8
V104 12AU8
V105 6CL6
V106 6CL6
S102-1F
S102-1R
S102-2F
S102-2R
S101-1F
S101-1R
S101-2F
S101-2R
S101-3F
S101-3R
S103 NOTE 7
Y AMPLITUDE
Y AMPLITUDE DC BAL
DYNAMIC BAL
Y CAL ADJ
Y POSITION
Y LIN
Y MULT BAL
GRID CURRENT ADJ
0.5V CAL SIG FROM L.V. SUPPLY SCHEMATIC
TO CRT, BEAM GATE & PF SUPPLY SCHEMATIC
INTERNAL SYNC TO SYNC AND SWEEP SCHEMATIC
+400V
+150V
-85V
NOTES:
1- RESISTANCE VALUES IN OHMS; K = THOUSAND, M = MILLION.
2- CAPACITANCE VALUES IN μμf UNLESS OTHERWISE SPECIFIED.
3- FRONT PANEL FACILITIES ARE UNDERLINED
4- ROTARY SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE, ARROW INDICATES CLOCKWISE ROTATION
5- INDICATES SERVICE ADJUSTMENTS.
6- INDICATES FRONT PANEL SCREWDRIVER CONTROL
7- S103 IS NORMALLY IN POSITION SHOWN; IS ACTUATED WHEN R131 IS ROTATED FULLY CLOCKWISE
8- COMPONENTS ARE IDENTICAL IN CHANNEL A AND B. TO FACILITATE TABULATION OF THE ELECTRICAL PARTS LIST, ZERO IS APPENDED TO ABOVE COMPONENTS TO DENOTE CHANNEL B SERIES, I. E., CHANNEL B DESIGNATION FOR V101 WOULD BE V1010 ETC.

Figure 5-1
Schematic, Vertical Deflection Amplifier
(9800 1531-4, Sheet 1 of 5)



NOTES:

1. CAPACITANCE VALUES IN μμf UNLESS OTHERWISE SPECIFIED.
2. FRONT PANEL FACILITIES ARE UNDERLINED.
3. ROTARY SWITCHES ARE SHOWN FULLY COUNTER-CLOCKWISE; ARROW INDICATES CLOCKWISE ROTATION.
4. ⊘ INDICATES SERVICE ADJUSTMENTS.
5. RESISTANCE VALUES IN OHMS; K=THOUSAND, M=MILLION.

Figure 5-2
Schematic, Horizontal
Deflection Amplifier
(9800 1531-4, Sheet 2 of 5)

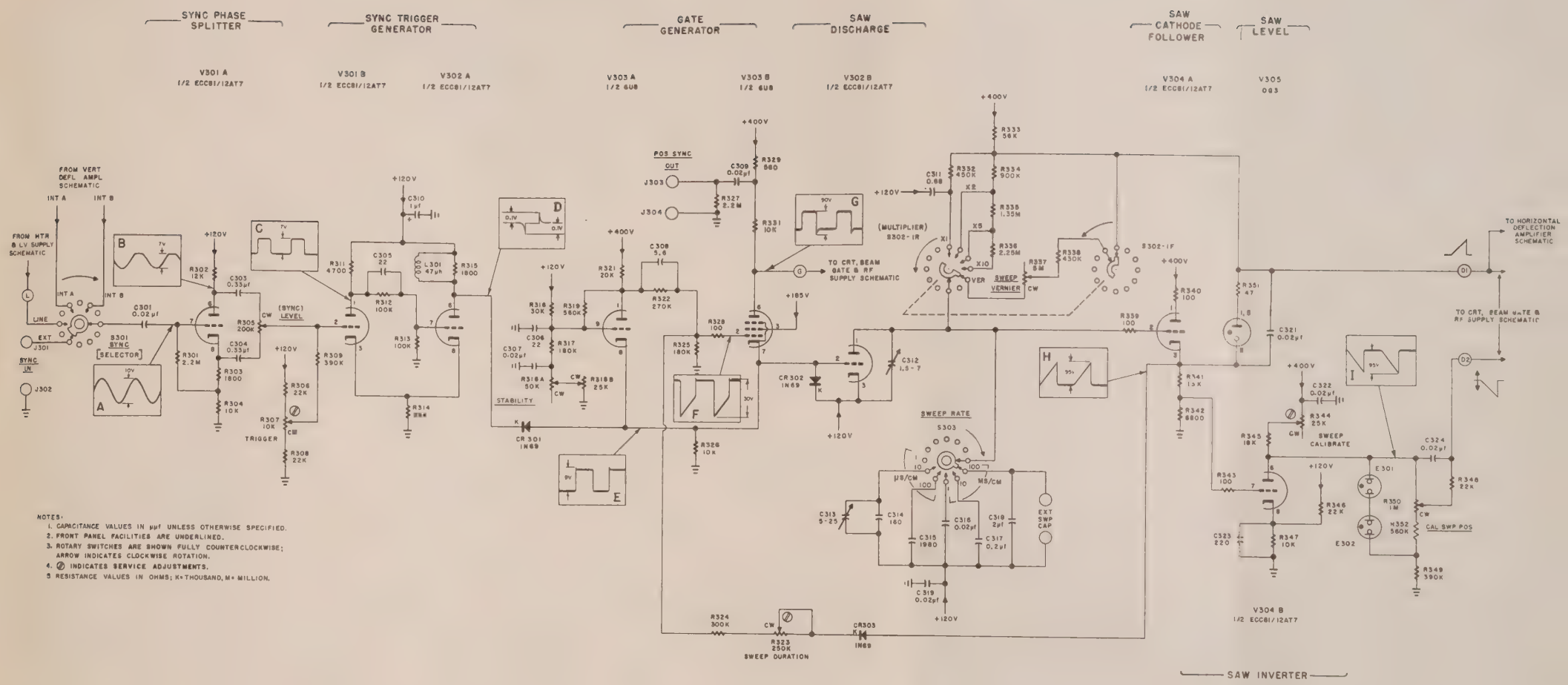


Figure 5-3
Schematic, Sync and
Sweep Circuits
(9800 1531-4, Sheet 3 of 5)

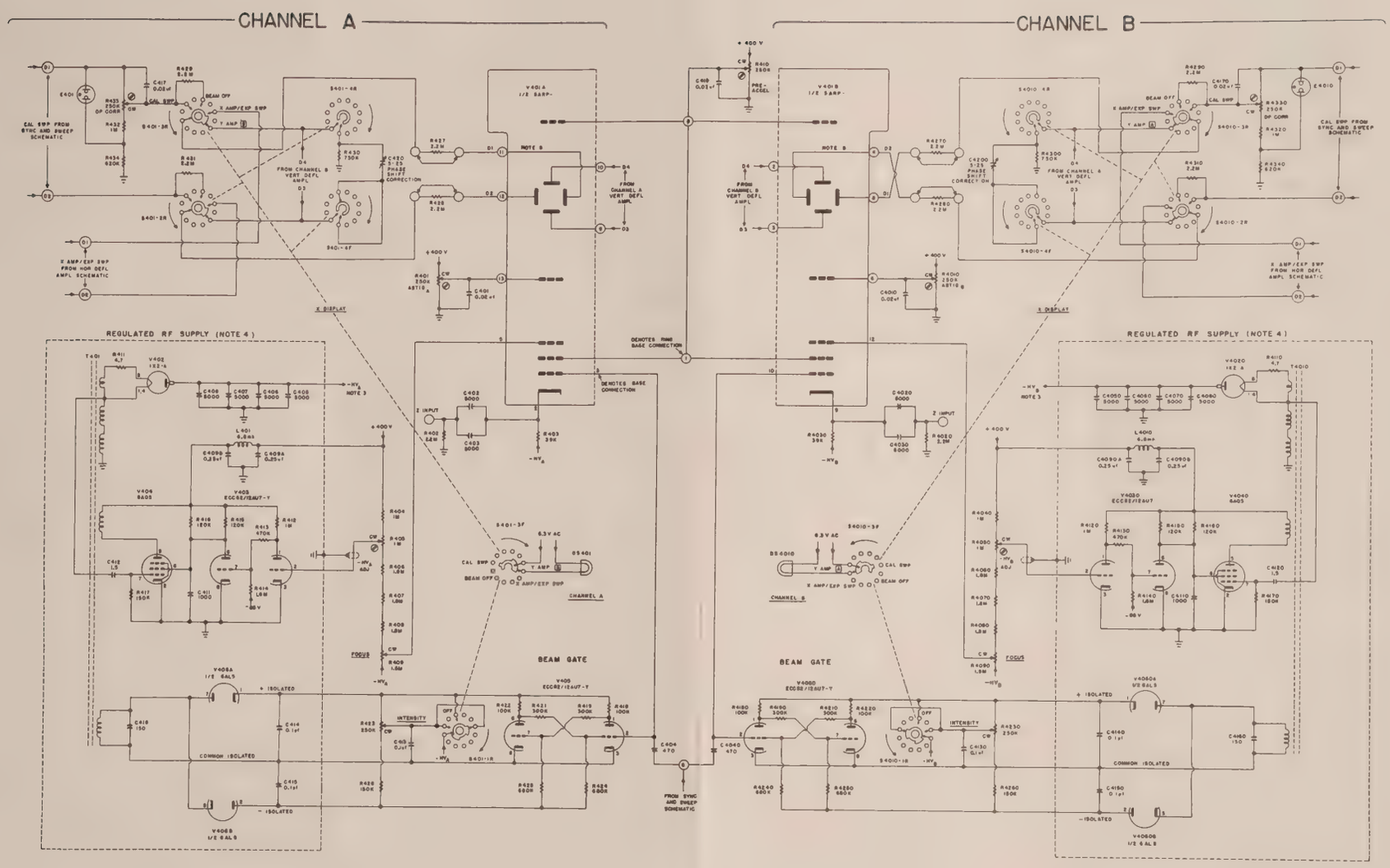
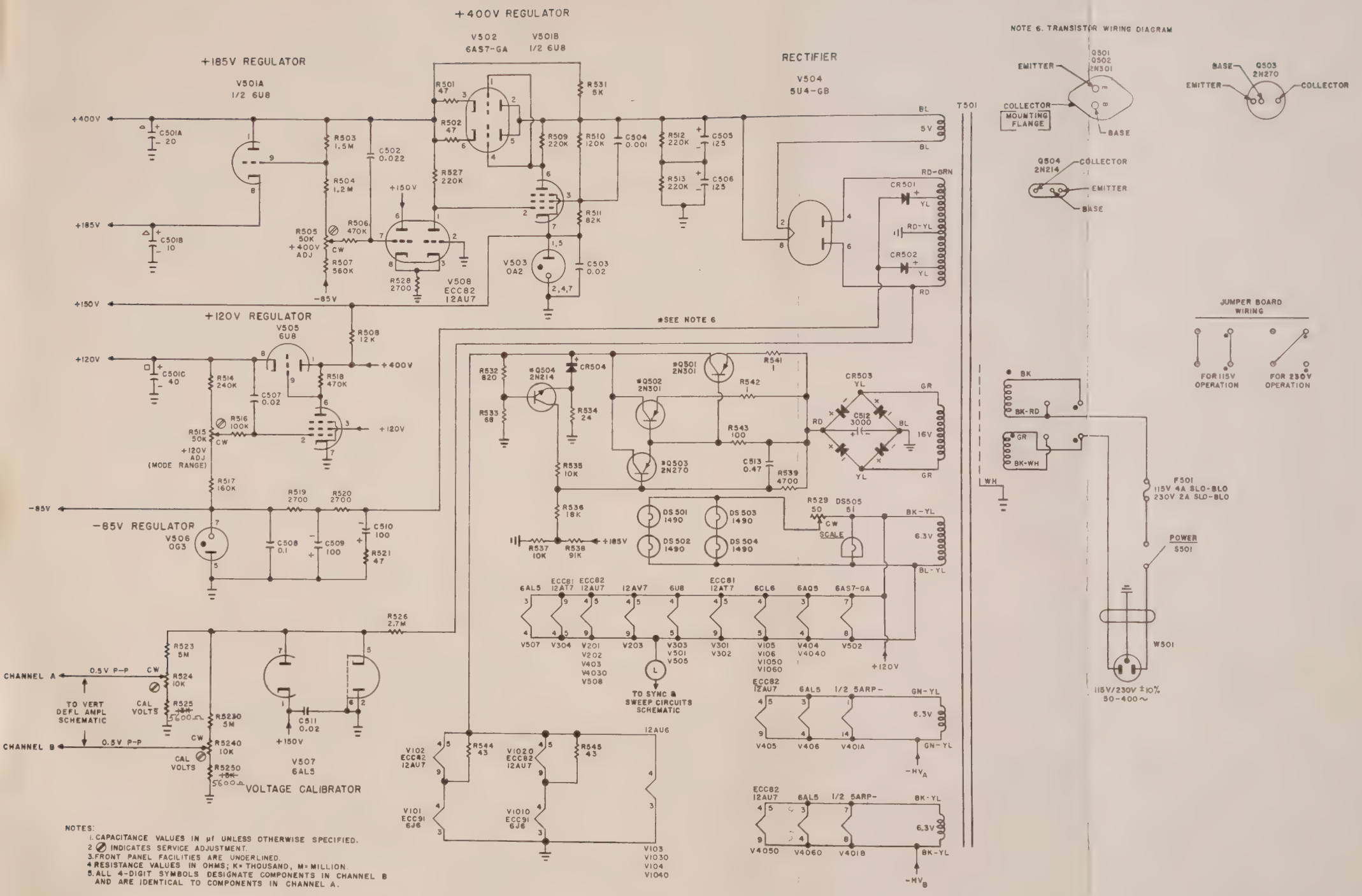

CHANNEL A
CHANNEL B
REGULATED RF SUPPLY (NOTE 4)
REGULATED RF SUPPLY (NOTE 4)
X DISPLAY
X DISPLAY
BEAM GATE
BEAM GATE
CHANNEL A
CHANNEL B
NOTES
1 - RESISTANCE VALUES IN OHMS, K = THOUSAND M = MILLION
2 - CAPACITANCE VALUES IN µµf UNLESS OTHERWISE SPECIFIED
3 - -HV IS SET TO 8500 VOLTS MEASURED WITH RESPECT TO THE ARM OF PRE-ACCEL R410.
4 - ALL GROUNDS IN REGULATED RF SUPPLY ARE MADE TO SHIELD CAN WHICH IS TURN IS TIED INTO THE COMMON GROUND SYSTEM AT ONE POINT.
5 - ROTARY SWITCHES ARE SHOWN FULLY COUNTERCLOCKWISE; ARROW INDICATES CLOCKWISE ROTATION
6 - FRONT PANEL FACILITIES ARE UNDERLINED.
7 - ⊘ INDICATES SERVICE ADJUSTMENT.
8 - DEFLECTION PLATES SHOWN AS VIEWED FROM FRONT OF TUBE

Figure 5-4
Schematic, CRT, Beam
Gate and RF Supply
(9800 1531-4, Sheet 4 of 5)



NOTES:
1. CAPACITANCE VALUES IN μf UNLESS OTHERWISE SPECIFIED.
2. ⊘ INDICATES SERVICE ADJUSTMENT.
3. FRONT PANEL FACILITIES ARE UNDERLINED.
4. RESISTANCE VALUES IN OHMS; K = THOUSAND, M = MILLION.
5. ALL 4-DIGIT SYMBOLS DESIGNATE COMPONENTS IN CHANNEL B AND ARE IDENTICAL TO COMPONENTS IN CHANNEL A.

Figure 5-5
Schematic, Low-voltage and Heater Supply
(9800 1531-4, Sheet 5 of 5)

ADDENDUM

FOR INSTRUCTION MANUAL OF

TYPES 411 and 411-R OSCILLOSCOPES (Manual #6703 2901)

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1. PARTS LIST CHANGES

The changes described below were made in order to change from VOLTS PER DIVISION to VOLTS PER CENTIMETER.

	Symbol		Part Number	Description
Change	R525 & R5250	from	0228 5690	Resistor, fixed, film, 13K ohms, ±1%, 1/2 watt
	R525 & R5250	to	0228 5560	Resistor, fixed, film, 5600 ohms, ±1%, 1/2 watt.

2. SCHEMATIC CHANGES

On Schematic Drawing 9800 1531-4, Sheet 5 (Figure 5-5), change R525 and R5250 from 13K ohms to 5600 ohms.

3. TEXT CHANGES

a. All references to VOLTS PER DIVISION should be changed to read VOLTS PER CENTIMETER throughout the entire Instruction Manual.

b. In Table 1-1, the information under "Vertical Scale Division" is revised as follows:

1) Major division..... 1 centimeter; 10 major divisions total 10 centimeters full scale

2) Minor division..... 0.2 centimeter; located on vertical center line

c. In Table 1-1, add the following note to item 2-2, "Input Sensitivity Range":

NOTE: When the Y amplifier is switched to the X deflection plates, the sensitivity of the amplifier is reduced; hence, a one millivolt full-scale pattern may not be obtained.

d. In Table 1-1, the vertical "Deflection Sensitivity" of item 2-4 is revised as follows:

1) Through Amplifier at Full Gain . . 100 microvolts dc or peak-to-peak per centimeter.

2) At Deflection Plates . . . . . 13.8 volts dc or peak-to-peak, ±10%, per centimeter

e. In Table 1-1, under the heading "Amplitude Calibration", change the amplitude of the calibration signal from 0.5 volt to 0.25 volt ±2%.

f. Section 2, Operation, paragraph 2-7b: Step 2 of the Y Calibration procedures is revised as follows:

2) Set Y CAL ADJ to give exactly half-scale deflection (5 centimeters) as indicated by the calibration mark on the engraved scale.

g. Section 2, Operation, paragraph 2-8c: The formula for the voltage gain of the amplifier is revised as follows:

The voltage gain per centimeter of the amplifier is equal to:

$$\frac{E_{out}}{E_{in}} \quad \frac{13.8 \text{ volts}}{\text{VOLTS PER CENTIMETER times (MULTIPLIER) setting}} \quad ; \pm 10\%$$

h. Section 4, Maintenance, Table 4-2, Service Adjustment Chart: The Cal Volts service adjustment procedure is revised as follows:

CAL VOLTS (R524 & R5240)	R524 is used to set the output of the voltage calibrator to 0.25 volt 1. Set VOLTS PER CENTIMETER to 1 DC and (MULTIPLIER to X.1) 2. Apply a ~~0.5~~ 0.25 volt signal from an external voltage calibrator to Y INPUT 3. Advance Y AMPLITUDE control for exactly half-scale deflection as indicated by the calibration marks on the engraved scale 4. Set (MULTIPLIER) to CAL 5. Adjust R524 (R5240) for the same half-scale deflection

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5. Notice of LOSS or DAMAGE should be given delivering Carrier's Agent by telephone or in person and confirmed by mail within 48 hours, if impractical to inspect shipment immediately.

All goods of our manufacture are carefully inspected and shipped in packages approved by Consolidated Freight Classification. The Railroads and Motor Carriers are reluctant to make adjustment for damaged merchandise unless reported and inspected PROMPTLY after arrival.

6. Title to merchandise returned to Allen B. Du Mont Laboratories, Inc. under warranty that is damaged in shipment will remain with the buyer and it will be the buyer's responsibility to file a claim with the carrier involved. To extend you every cooperation, the Traffic Department of Allen B. Du Mont Laboratories, Inc. will secure an inspection report from the carrier and forward it to the buyer when it is necessary for a claim to be filed.

7. To obtain "In Warranty Service", or repairs to any Du Mont instrument damaged in transit, the instrument should be carefully packed and forwarded to the nearest Du Mont Authorized Service Depot or to the Factory Service Department at 760 Bloomfield Avenue, Clifton, New Jersey, transportation PREPAID. A copy of the signed inspection report should be included with the shipment. For a list of these Authorized Service Depots — see reverse side of this sheet.

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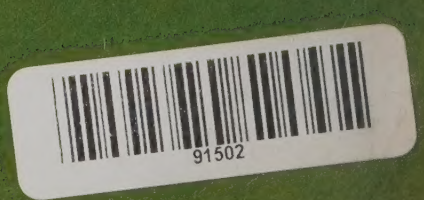
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